JUN 9 1924

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ENGINEERING:

An Illustrated Weekly Journal.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXVII.—No. 3048.] *LONDON: FRIDAY, MAY 30, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd., ROCHESTER.

Steam & Crude Oil Rollers. SPECIAL ROLLERS FOR BITUMINOUS ROADS. 1869

A. G. Mumford, Ltd., CULVER STREET WORKS, COLCHESTER. ON ADMIRALTY AND WAR OFFICE LISTS. ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS. See advertisement page 13. PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS. And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant OF ALL DESCRIPTIONS. FLOATING CRANES. COAL BUNKERING VESSELS.

Werf Conrad, HAARLEM, HOLLAND. Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.2. *See half-page Advert. last week and next week.* 2087

CRANES. All Types. GEORGE RUSSELL & CO., LTD., Motherwell. 1867

STEEL TANKS, PIPES, GASHOLDERS, &c.

Thos. Piggott & Co., Limited, BIRMINGHAM. 1241 See Advertisement last week, page 19.

Spencer-Hopwood & Kirke PATENT BOILERS *See Page 75.* 1994 Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives. Specification and Workmanship equal to Main Line Locomotives. R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1884

P. & W. MacLellan, Ltd., CLUTHA WORKS, GLASGOW. MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION. RAILWAY IRONWORK, BRIDGES, ROOFING, &c. Chief Offices: 139, Trongate, Glasgow. Od 8547 Registered Offices: Clutha House, 10, Princes St., Westminster, S.W.1.

Brett's Patent Lifter Co. LIMITED. Hammers, Presses, Furnaces, COVENTRY. 610

Invincible Gauge Glasses. *BUTTERWORTH BROS., Ltd., Newton Heath Glass Works, Manchester.* Od 9753

GEARS OF EVERY DESCRIPTION. Spring Grove, AUTOGEARS (LEEDS), LTD., Hyde Park Road, Leeds. 2153

Fuller, Horsey, Sons & Cassell. SPECIALISTS in the SALE AND VALUATION of PLANT AND MACHINERY and ENGINEERING WORKS. 11, BILLITER SQUARE, E.C.3. 1834

Iron and Steel Tubes and Fittings. Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817 The Scottish Tube Co., Ltd. HEAD OFFICE: 34, Robertson Street, Glasgow. See Advertisement, page 57.

YARROW & CO. (1922), LTD., GLASGOW. PASSENGER AND CARGO STEAMERS. SHALLOW DRAFT VESSELS. 1553

Campbells & Hunter, Ltd. Gear Cutting. Worm Wheels cut up to 13 ft. diam. Bevel and Mitre Wheels planed up to 3 ft. diam. Spur Wheels cut up to 9 ft. diam. DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & Co., LTD., PORTSMOUTH, SHIP & LAUNCH BUILDERS, Od3581 ENGINEERS & BOILER MAKERS.

THE GLASGOW ROLLING STOCK AND PLANT WORKS. Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS. PRESSED STEEL WORK OF ALL KINDS. Od3382 Reg. Office and Chief Works: Motherwell. London Office: 32, Great St. Helen's, Bishopsgate, E.C. 3.

OIL FUEL APPLIANCES, *Systems* PRESSURE, AIR, STEAM *For Boilers of all types.* KERMODES LIMITED, 35, The Temple, Dale Street, Liverpool. *Naval Outfits a Speciality,* also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds. Supplied to the British and other Governments. Telephone No.: Central 2832. Telegrams: "Warmth." 4078

Locomotives Tank Engines designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2487 See their Illus. Advertisement, page 95, last week.

Gearing of all Descriptions. GEAR WHEELS up to 10 ft. diameter. FLY ROPE and SPUR DRIVING WHEELS up to 26 ft. diameter. BRICK and CLAYWORKING MACHINERY of all kinds. ENGINES:—"Unidow," "Corliss," or Drop Valve. CLAYTON, GOODFELLOW & CO., LTD., Blackburn. 1349

R. Y. Pickering & Co., Ltd. (Established 1864.) BUILDERS of RAILWAY CARRIAGES & WAGONS MAKERS of WHEEL and AXLES of all kinds RAILWAY WAGONS FOR HIRE. Chief Works and Offices: WISHAW, near GLASGOW. London Office: 3, VICTORIA STREET, WESTMINSTER, S.W. Od 8353

Patents.—Exhibition Visitors can obtain information respecting patents, etc., from B. T. KING, Regd. Patent Agent, 146a, Queen Victoria St., E.C.4. For free appointment Wembley Exhibition, 'Phone Central 682. Handbook free.

For Your Repairs or any SPECIAL MACHINERY, try THOMAS HUNT & SONS, Alden Ironworks, Bridge Road West, Battersea, S.W. 11. Est. 1864. 2213

E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1738 & 1737. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

Rosser and Russell, Ltd., MECHANICAL ENGINEERS, QUEEN'S WHARF, HAMMERSMITH, W. Undertake SPECIAL MACHINE WORK of any description. WELL EQUIPPED SHOP. LATHE WORK up to 10 ft. diameter. 'Phone: Hammersmith 31, 907. 9211

John Bellamy, Limited, MILLWALL, LONDON, E. 1216 GENERAL CONSTRUCTIONAL ENGINEERS, Boilers, Tanks, & Mooring Buoys STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL Tubes AND Fittings AND Steel Plates.

STEWARTS AND LLOYDS, Ltd. GLASGOW BIRMINGHAM LONDON. See Advertisement, page 7. 1873

Peter Brotherhood Ltd., PETERBOROUGH. STEAM ENGINES AND TURBINES. GAS AND OIL ENGINES. AIR COMPRESSORS. REFRIGERATING PLANT. 1475 See Advertisement, page 55, May 23.

ON ADMIRALTY LIST.

John Kirkaldy, Ltd., London Office: 101, LEADENHALL ST., E.C.3. Works: BURNT MILL, near HARLOW, ESSEX. Makers of Evaporating and Distilling Plants. Refrigerating and Ice-making Machinery. Feed Water Heaters. Evaporators. Fresh Water Distillers. Main Feed Pumps. Combined Circulating and Air Pumps. Auxiliary Surface Condensers, &c., &c. 1586

Important French Firm, well introduced among Manufacturers, and Government Contractors, WISHES to OBTAIN the SOLE AGENCY (with or without warehousing) of a manufacturer of patented, up-to-date and special mechanical apparatus, machinery or tools (small or heavy) for metal or wood-working purposes. Would be responsible for accounts. First-class references in England, U.S.A., and France. Write, giving full particulars, to SOCIETE DESHAYES FRERES, 176, Quai de Jemmapes, Paris. D650

Iron Castings up to 1 ton weight. Enquiries invited. COCHRAN & CO., Annan, LTD., Annan, Scotland. 2106

MACHINE CUT Gears. Spurs, Bevels, Spiral, Worm and Worm Wheels. HIGHFIELD GEAR CUTTING CO. (Dept. E.), Huddersfield. 1645

HEAT INSULATION. CELITE PRODUCTS CORPORATION, Windsor House, Westminster, S.W.1. 1673 See our Illustrated Advertisement, May 9.

James D. Roots.—Patents. BRITISH and FOREIGN. Moderate charges. Long and varied practical Engineering experience valuable to Inventors. Formerly many years contributor of Patents Abstracts for "The Engineer" & "The Times."—Thanet House, Temple Bar, London, W.C.2.

Telegrams: "Ipa," London. Telephone: 7424 Central. E. P. Alexander & Son. CHARTERED PATENT AGENTS, 306, High Holborn, London, W.C. 1. 585 PATENTS. DESIGNS. TRADE MARKS.

Semi-Automatic METALLOGRAPHY —at the rate of over 100 per hour at × 100. F. DAVIDSON & CO., 29, Great Portland St., London, W.1. 2114

Royles Limited, ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALORIFIERS EVAPORATORS, CONDENSERS, AIR HEATERS, } ROYLE'S PATENTS, Merrill's Patent TWIN STRAINERS for Pump Suctions. SYPHONIA STEAM TRAPS, REDUCING VALVES. High-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 5723

YARROW & CO. (1922), LTD., GLASGOW. LAND AND MARINE YARROW BOILERS. 1553

Matthew Paul & Co., Ltd. LEVENFORD WORKS, Dumbarton. 2212 See Full Page Advt., page 63, May 23.

Forgings. Walter Somers, Limited, HALESOWEN. 7116

Taylor & Challen Presses For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER. Foundry, Works and Showrooms: BIRMINGHAM. See Advert., page 60, May 23. 8195

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS. Forgings, Castings, Bars, Sheets, Wire, Tubes. THE DELTA METAL CO., LTD., 2033 E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

Technical Translations from or into Spanish, Italian, French, German, Russian, &c., by experts.—VICTORIA TRANSLATION BUREAU, 21a, Southampton Bldgs., Chancery Lane, W.C. 2

Railway Switches and Crossings. T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

RAILWAY AND TRAMWAY ROLLING STOCK. Hurst, Nelson & Co., Ltd., THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

Important.—For Immediate SALE AT LOW PRICES. One Superior 400 Kw. Howden - Siemens ELECTRIC GENERATING SET, 250 volts D.C., 350 r.p.m., 155 lbs. pressure. One High-Class Horizontal Side - by - Side COMPOUND CORLISS ENGINE, 200 I.HP. at 80 r.p.m., belt flywheel 12 ft. diameter by 2 ft. 6½ in. on face, very suitable for export, for driving factory, sawmill, etc. One Powerful Set COMPOUND HORIZONTAL HYDRAULIC PUMPING ENGINES, by Sir Wm. Arrol & Co., capacity 200 gallons per minute. Two Steamdriven CENTRIFUGAL PUMPS, by Drysdale, capacity 1250 and 1390 gallons per minute. In new condition and all seen here at Glasgow. JOHN H. RIDDELL LTD., 40, St. Enoch Square, Glasgow. 2191

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD., London Office—12, Victoria Street, S.W. MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES. CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1943

Centrifugals. Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 1676 See half-page Advertisement, page 73, May 9.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

Civil Service Commission.

—FORTHCOMING EXAMINATION. MALE CARTOGRAPHER in the Hydrographic Department of the Admiralty (19—25, with extension in certain cases), 10th July.

The date specified is the latest on which applications can be received. They must be made on forms to be obtained, with particulars, from THE SECRETARY, Civil Service Commission, Burlington Gardens, London, W.1. D 909

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 2108

T. G. Howes Thomas, (Inst.

C.E. Coach, late of Westminster), Consulting Engineer, has resumed his "Up-to-date" Coaching by correspondence, and is prepared to advise on proposed or accepted patents.

34, Baldwin Street, Bristol. D 847

TENDERS.

The Director-General,

India Store Department, Branch No. 16. Belvedere Road, Lambeth, S.E. 1, REQUIRES:—

1. VACUUM BRAKE GEAR.
2. VACUUM EXHAUSTERS with Oil Engines for driving, 1-0 to 200 c. feet per minute.
3. GALVANIZED STRAND WIRE.
4. WROUGHT IRON FIRE BAR, rolled section.
5. FILES

Tenders due on the 17th June, 1924, for No. 1, on the 20th June, 1924, for No. 2, and on the 27th June, 1924, for Nos 3 to 5.

Tender forms obtainable from above. D 921

COUNTY BOROUGH OF ST. HELENS.

REDGATE BRIDGE.

The Corporation of St. Helens are prepared to receive

Designs and Tenders for the

CONSTRUCTION in STEEL and ERECTION of a new MOVABLE BRIDGE in lieu of the existing Swing Bridge over the Canal at Redgate within the Borough.

Plan of site and particulars may be obtained on application to Mr. ARTHUR W. BRADLEY, M.Inst. C.E., the Borough and Water Engineer, St. Helens.

Sealed Tenders, on the form and in the envelope provided, to be delivered on or before the 30th day of June.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. H. ANDREW,
Town Clerk

Town Hall, St. Helens.
May, 1924. D 878

BALLINASLOE MENTAL HOSPITAL.

TO BOILER MAKERS.

The Committee of Management of above Institution will, at its meeting to be held on Monday the 9th day of June, 1924, consider

Tenders from Competent

Persons for REPAIRS to TWO CORNISH BOILERS. The repairs include fitting of Mild steel plates to wasted part of furnaces, fitting new blow-down valves to elbow pipes, supply and fit new mud-block, scale clean and remove all deposit, etc.

Engineer's specification can be had on application.

Tenders, marked "Boilers," addressed to the Resident Medical Superintendent, to be lodged before Saturday the 7th June, 1924.

The lowest or any Tender not necessarily accepted.

By order of the Committee

JOHN MILLS,
Resident Medical Superintendent.

13th May, 1924. D 867

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for :—

47 "H" CLASS SUPERHEATED LOCOMOTIVES, 5 ft. 6 in. gauge.

Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C. 2, on or after 29th May, 1924.

A fee of 20/- will be charged for the specification, which is NOT returnable.

Tenders must be submitted not later than NOON, on Friday, 13th June, 1924.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the orders.

By Order of the Board,
R. C. VOLKERS,
Secretary.

D 923

FOR SALE, BUSINESS of the WALKER-HANNA BEARINGS, LIMITED (now in Liquidation) of Great Jackson Street, West Gorton, MANCHESTER.

Tenders are Invited for the

whole ASSETS of the above Company including MACHINERY, PLANT, STOCK, etc., amounting as per valuation dated 8th May, 1924, to £1450.

The Buildings are Leasehold and have been partly erected by tenants. The rent is £70 per annum.

Copies of Inventories may be seen either at the Liquidator's Office or at the Works, Great Jackson Street, West Gorton, Manchester.

The highest or any offer may not be accepted.

Tenders must be lodged with the Liquidator not later than 4th June, 1924.

Further information may be obtained from the Liquidator, HAROLD J. MACLEISH, C.A., 116, Hope Street, Glasgow. D 809

MIDLAND GREAT WESTERN RAILWAY OF IRELAND COMPANY.

TENDERS FOR THE SUPPLY OF STEELWORK FOR STATION ROOF, SLIGO.

The Directors of the above named Company are prepared to receive

Tenders for the Supply of

STEELWORK for NEW STATION ROOF at Sligo.

Drawings and Specification can be had on application to the Company's Chief Engineer, Broadstone Terminus, Dublin, on payment of £1, which is not returnable.

Tenders, sealed and endorsed "Tender for Steelwork for Sligo Station Roof" to be forwarded addressed to the "Chairman," Midland Great Western Railway, Broadstone Terminus, Dublin, so has to reach him not later than Ten a.m. on Monday, 16th day of June, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

EDWARD H. TAYLOR,
Acting Secretary.

Broadstone Terminus,
Dublin.
22nd May, 1924. D 882

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY LIMITED.

THE ROHILKUND AND KUMAON RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :—

36 THIRD CLASS BOGIE CARRIAGES, TWO FIRST AND SECOND CLASS COMPOSITE BOGIE CARRIAGES,

as per specification to be seen at the Company's Offices.

Tenders addressed to the undersigned, and marked "Tender for Carriages," or as the case may be, with name of firm tendering, to be lodged not later than Noon on Tuesday, the 24th day of June, 1924.

For each Specification a fee of £1 will be charged which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. A. NEVILLE,
Managing Director,
Secretary.

237, Gresham House,
Old Broad Street, London, E.C. 2.
26th May, 1924. D 900

STATE ELECTRICITY COMMISSION OF VICTORIA.

Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/45—
66,000 VOLT INSULATORS.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract, and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10/6 each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £50 is to be lodged with Tender.

The Specifications may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 4th August, 1924.

R. LIDDELOW,
Secretary. D 833

COUNTY OF LONDON.

The London County Council invites

Tenders for Three Self-

contained PUMPING SETS for Shad Thames Pumping Station, Bermondsey, London, S.E. 1. Each set to comprise a 3-cylinder Vertical Gas Engine, coupled direct to a Centrifugal Pump capable of discharging 75 tons of storm-water per minute.

Persons desiring to submit Tenders, may obtain, on and after Monday, the 2nd June, 1924, the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W. 1, upon payment of the sum of £5 by cheque or draft to the order of the London County Council. This amount shall be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained upon personal application, and the drawings, specification and other contract documents may be inspected at the Old County Hall before payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after Four p.m. on Monday, the 30th June, 1924, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. D 894

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of :—

1. PAINTS, DRYSALTERIES, etc.
2. LEATHER HIDES, etc.
3. INDIA RUBBER GOODS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked:—"Tender for Paints, Drysalteries, etc.," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 13th June, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 2s. 6d. for each copy of each Specification.

Copies of the drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
27th May, 1924. D 925

APPOINTMENTS OPEN.

Young Graduate in Physics

REQUIRED for work in Test Room and Experimental Department.—Apply to CAMBRIDGE INSTRUMENT COMPANY, LIMITED, Cambridge, giving particulars of other subjects taken, and any postgraduate or workshop experience. Some Engineering experience an advantage, but not essential. D 870

KARACHI PORT TRUST.

ASSISTANT SUPERINTENDENT OF MACHINERY.

The Trustees of the Port of Karachi invite

Applications for the Post of

ASSISTANT SUPERINTENDENT OF MACHINERY, Manora.

Applicants must be about 30 years of age and have served an apprenticeship in some recognized Engineering and Shipbuilding Works and must have a first class Engineer's Board of Trade Certificate.

Dredging experience would be a recommendation and applicant must be able to control large gangs of labour.

SALARY. Rs.550/- rising by annual increments of Rs. 25/- for approved service to Rs. 800/- per calendar month with free house.

The appointment will be probationary for six months and will be confirmed after that period.

The successful candidate will be granted Second Class Railway and Steamer fares to Karachi.

All officers of the Port Trust are required to join the Port Trust Provident Fund on confirmation. Leave and leave allowances will be given in accordance with the rules for the time being in force.

Applications, with COPIES ONLY of testimonials and further particulars of age and place of birth, educational and practical qualifications, present or last employment experience, to be addressed to Messrs. RENDEL, PALMER & TRITTON (Agents and Consulting Engineers to the Trust), 12-14, Dartmouth Street, Westminster, London, S.W.1, so as to be received not later than the 10th June, 1924. D 924

MINISTRY OF HEALTH.

ENGINEERING INSPECTOR.

Applications are Invited

by the Minister of Health for one Vacant POST of ENGINEERING INSPECTOR.

The salary commences at £600 per annum and rises by yearly increments of £25 to a maximum of £1000. In addition to the salary a bonus which varies with the cost of living is payable. The appointment will carry the usual Civil Service conditions as to pension, holidays, etc.

Candidates must be between the ages of 30 and 45 and be Chartered Civil Engineers having had wide experience in the designing and carrying out of works, especially waterworks, sewerage and sewage disposal. Experience in reinforced concrete construction is desirable.

The Inspector will be required to devote his whole time to the Public Service and must be prepared to take up his duties on appointment. The Headquarters of the Engineering Inspectors are in London.

Canvassing Members of Parliament or Officers of the Ministry will render a candidate liable to disqualification.

Applications, giving age and details of career (including Military Service) and accompanied by three recent testimonials, should be made in writing to the DIRECTOR OF ESTABLISHMENTS, MINISTRY OF HEALTH, Whitehall, S.W.1, before 14th June, 1924. D 896

ASSISTANT MASTER, H.M. DOCKYARD SCHOOLS.

Applications are Invited

for APPOINTMENT as ASSISTANT MASTER in H.M. Dockyard Schools.

Candidates should hold a University degree, with Honours in Science or Engineering, and should have had experience in teaching and in laboratory work. They must be medically fit.

Subjects taught in the schools include Mathematics, Applied Mechanics, Magnetism and Electricity, Heat, Metallurgy, Mechanical Drawing and English.

The appointments will be for one year on probation, but subject to satisfactory reports, successful candidates will be confirmed and placed on the establishment.

Salary scale £180, £10, £240, £15, £450, with bonus depending on cost-of-living figure; the present bonus payable on £180 is £67, and on £450 is £137. Pension on Civil Service scale.

Two vacancies will be filled; in the schools at Devonport and Rosyth respectively; and selected candidates will be required to commence duty on 1st September.

Applications, with copies of testimonials and evidence of teaching ability, should be forwarded not later than 14th June to:—

THE SECRETARY OF THE ADMIRALTY (C.E.), Whitehall, London, S.W.1. D 897

THE RESEARCH ASSOCIATION OF BRITISH MOTOR AND ALLIED MANUFACTURERS, 15, Bolton Road, W.4.

Research Assistant Required

chiefly for work on Strength of Materials.—Salary according to qualifications and previous experience.—Apply, by letter only, marked "Application," to the SECRETARY. D 911

BOMBAY BARODA AND CENTRAL INDIA RAILWAY.

Bridge Superintendent in

INDIA.

This Superintendent is Required Immediately for steel bridge erection, including underwater foundations and pile screwing. Candidates should be not more than about 35 years of age, and be able to make out proper reports, etc., concerning the progress of the work.

SALARY. Up to Rs. 750 per calender month according to age and qualifications.

TERMS. Three years' agreement in the first instance, second class free passage to India and home again on satisfactory termination of service. The selected candidate will only be appointed subject to passing strict medical examination by the Company's Consulting Physician.

Candidates must give their age and state whether married or single and family (if any), also particulars of training and subsequent experience, giving the names of railways or bridge building firms by whom candidates have been employed and the class of work employed upon from time to time with dates in each case. They should state whether they have been employed abroad before and if so, in what capacity, and with whom and the reason for leaving the service, and should submit a copy of leaving certificate.

Letters of application, together with copies, NOT ORIGINALS, of testimonials should be addressed to the undersigned not later than the 14th June, 1924.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
91, Petty France,
Westminster, S.W.1.
28th May, 1924. D 930

TECHNICAL COLLEGE, BRADFORD.

Applications are Invited for

APPOINTMENT as HEAD OF THE BUILDING and CIVIL ENGINEERING DEPARTMENT in the College.

Commencing salary (in accordance with Burnham Scale) £600 per annum.

Full particulars of the appointment and forms of application may be obtained from the Principal of the College. Applications should be sent to me not later than 9th June.

N. L. FLEMING,
Town Clerk.

20th May, 1924. D 831

THE COMMISSIONERS FOR THE PORT OF CALCUTTA.

Applications are Invited for

the POST of ASSISTANT ELECTRICAL ENGINEER. Salary Rs. 700 per mensem, rising by annual increments of Rs.50 per mensem to Rs.1050 per mensem. The candidate must possess good technical qualifications and a concise statement of these must be made in the application. Experience in the installation and maintenance of High Tension and Low Tension Switchgear, Transformers, Motors, Underground Cables and Overhead Transmission Lines is essential.

Applications, with copies of testimonials, should be sent to Mr. J. ANGUS, M.Inst.C.E., Clutha House, 10, Princes Street, Westminster, not later than 11th June, 1924. D 888

CITY OF LEICESTER WATER DEPARTMENT.

ASSISTANT ENGINEER.

The Water Committee are prepared to receive

Applications for the post of

ASSISTANT ENGINEER.

An inclusive salary at the rate of £400 per annum will be paid.

Applications stating age, experience, qualifications and present salary, together with copies of not more than three testimonials should be received by me not later than Noon, the 16th June, 1924.

Canvassing Members of the Committee will disqualify applicants.

G. T. EDWARDS, M.Inst.C.E.,
Water Engineer and Manager.

Water Works Office,
Bowling Green Street,
Leicester. D 887

CITY OF BIRMINGHAM—SALVAGE DEPARTMENT.

APPOINTMENT OF TWO ASSISTANT ENGINEERS.

Applications are Invited for

the APPOINTMENTS of ASSISTANT ELECTRICAL ENGINEER and ASSISTANT MECHANICAL ENGINEER. Applicants must be properly qualified Engineers and have had practical experience in the design, erection and maintenance of electrical or mechanical plant, including the control of workmen.

The commencing salaries will be £250 per annum plus a fluctuating bonus which at present amounts to £107 3s. 1d.

The Candidates appointed will be required to devote the whole of their time to the service of the Corporation. They must not be over 45 years of age, and they will be required to contribute to the Superannuation Scheme, for which purpose they must submit themselves to the Corporation Doctor for examination, the appointment being subject to the Doctor's report being satisfactory.

Applications, endorsed "Assistant Electrical Engineer" or "Assistant Mechanical Engineer," stating age, qualifications, and experience, and accompanied by not more than three recent testimonials, to be sent to the undersigned not later than Saturday, the 21st June, 1924.

Canvassing will be deemed a disqualification.

JAS. JACKSON,
Superintendent.

Salvage Department,
161, Corporation Street,
Birmingham.
30th May, 1924. D 877

BRITISH EMPIRE EXHIBITION; PUMPS AND PUMPING MACHINERY.—I.

OWING to obvious difficulties the range of pumping plant shown at the British Empire Exhibition, with a few exceptions, is confined to the smaller sizes and to pumps for special purposes. So far as it goes in this way, the machinery assembled is typical of good British practice, and though it is to be regretted that some firms are not represented, anyone particularly interested in this branch of engineering will find much to attract his attention. Many of the exhibitors are showing special types of machines, while centrifugals and turbine pumps are well represented. Among the smaller sizes are to be found oil fuel and oil transfer pumps, now used to a much greater extent, of course, than formerly, while small turbine driven boiler-feed centrifugal sets and vertical spindle centrifugals are also conspicuously numerous. Air pumps are also well represented. In the present articles we do not propose to classify the exhibits in any way. This would be difficult, indeed the range of pumps shown at the various stands would make such a task impossible to accomplish satisfactorily. It has, therefore, been thought best to select the more noteworthy examples shown and deal with each of them practically independently. In this article, of course, we do not cover more than a portion of the ground, and many interesting exhibits are unavoidably held over for the moment.

The largest pump actually to be seen at the exhibition is the 48-in. centrifugal pump, which is shown by Messrs. Worthington-Simpson, Limited, Kingsway, W.C. 2. This is one of four being supplied by this company to the Metropolitan Water Board for their new Littleton Reservoir, the largest artificial reservoir in the world. A description of this reservoir was given in ENGINEERING some time ago (see vol. cxiv, page 417), and reference may be made to this account in connection with the interesting intake works for which these pumps are being supplied. The pumps are of the low-lift type and are to pump water through pipes passing up over the reservoir embankment and down into the area enclosed, the actual discharge being into a concrete stilling basin. Drawings showing the rising mains passing over the embankment were given in Figs. 18 and 19, Plate XXXII, accompanying the article referred to above. An idea of the pumping conditions may be obtained from the fact that the level in the suction basin water will normally be at 39 ft. above O.D., with engine floor level at + 44 O.D. The top of the embankment will be at + 81 O.D., full water level being at + 75 O.D. The four delivery mains leave the pump-house at + 37 O.D., and on reaching the embankment are carried up this on a slope of 2¼ to 1. For a short length they run horizontally at an elevation of + 78 O.D., after which they turn down the inner slope on an incline of 2 : 1. In the stilling basin the water is held up by an 8-ft. weir, the crest of which is at + 45 O.D. The diameter of the delivery pipes is 60 in.

The pumps are each to deliver from 43,450 gallons per minute against 46 ft. head, to 60,800 gallons per minute against 30 ft. head, at speeds respectively of 130 and 140 r.p.m. This gives a capacity for the pumping plant of 250 million gallons for 24 hours against 46 ft. head, or 343 million gallons against 30 ft. head. The pumps will be driven direct by horizontal uniflow steam engines by the same builders, steam to which will be furnished by four Stirling boilers, with superheaters and mechanical stokers and four Green economisers. The brake horse-power of each unit working will be from 770 to 704. Two views of one of the pumps at Messrs. Worthington-Simpson's works at Newark are shown in Figs. 1 and 2, above. The pumps, as will be seen, draw on both sides of the impeller. The suction pipes are arranged parallel with the pump axis and the delivery leaves at right angles to this, the sets being laid out in the pumping station in *echelon*.

This pump is naturally the most prominent feature of Messrs. Worthington-Simpson's stand, which, however, contains a variety of smaller machines, most of which are of the reciprocating type, such as simplex and duplex vertical and horizontal feed pumps, as well as oil fuel pumps, &c. The firm's horizontal duplex cargo oil pump, fitted with pot valves, is also exhibited, but as this was fully illustrated and described in our issue of December 14 last (page 739), we would refer readers to that account of this particular machine.

Another fine example of machinery constructed for water works is the centrifugal set to be seen at the Stand of Messrs. Mather and Platt, Limited, of Manchester. This electrically-driven pump has a capacity of over 15,000,000 gallons for 24 hours, against a 140 ft. head, at 970 revolutions per minute. It is driven by a 580 h.p. Mather and Platt motor and is one of a set of seven of similar design constructed by this firm for the Calcutta Corporation Waterworks, of which Mr. J. R. Coats, M.Inst.C.E., is chief engineer, by whose permission the pump is shown. The pump is destined for the Mullick Ghat Pumping Station, Calcutta. The design is known as the maker's high efficiency "Medivane" pattern, the size in this case being 18 in. Other exhibits by the same firm include a six stage "Plurovane" high lift pump, and a fire pump with motor. The former has a capacity of 375 gallons per minute against a head of 500 ft. The speed is 1,450 r.p.m. and the pump is direct coupled to a Mather and Platt 85 horse-power mining type motor. We may also mention that in the Exhibition power station, Messrs. Mather and Platt have both a 10 in. and a 12 in. condenser circulating pump, having supplied also a condenser extraction pump. We may also refer to the original turbine pump made by the firm in collaboration with Prof. Osborne Reynolds, to be seen in connection with the exhibits in the Mining Hall adjacent to the Exhibition coal mine.

Messrs. John Cochrane (Barrhead), Limited, of Barrhead, near Glasgow, have on exhibition three centrifugal pumps which are typical of the firm's designs. One of these is a multi-stage turbine pump, another a single stage centrifugal, while the third is a special pump for paper pulp and heavy liquids. The turbine pump is of the ring type of design, enabling any desired number of stages to be

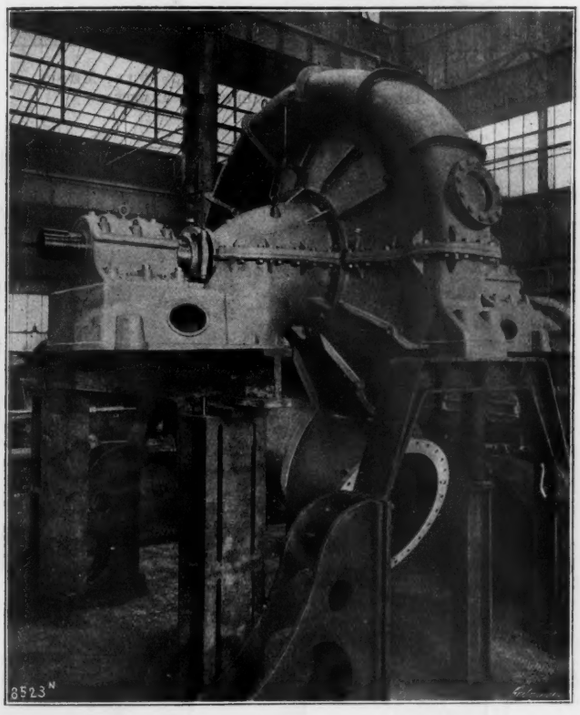


FIG. 1.

FIG. 2.

FIGS. 1 AND 2. 48-IN. LOW-LIFT CENTRIFUGAL PUMP FOR THE METROPOLITAN WATER BOARD; MESSRS. WORTHINGTON-SIMPSON, LIMITED.

CENTRIFUGAL PUMPS AT THE BRITISH EMPIRE EXHIBITION.

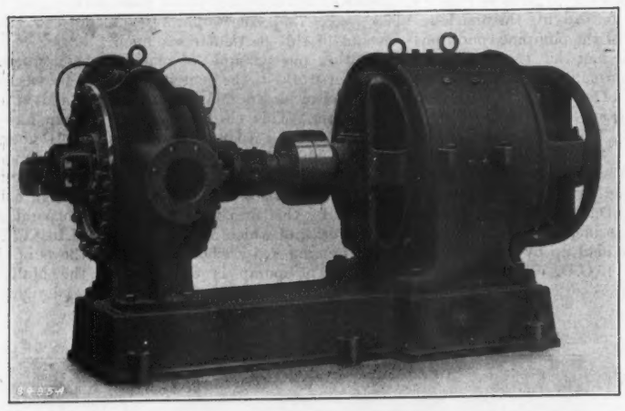


Fig. 3. Single Stage Centrifugal Set; Messrs. John Cochrane (Barrhead), Limited.

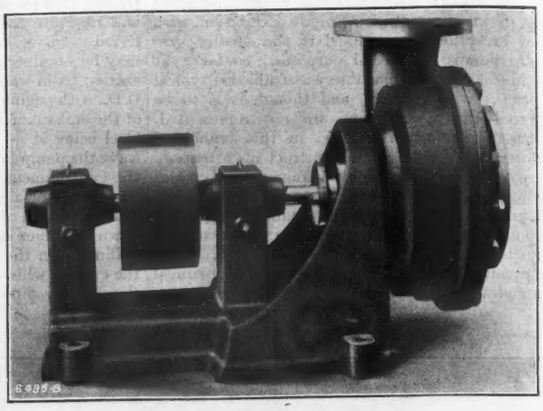


Fig. 4. Centrifugal Pump for Paper Pulp; Messrs. John Cochrane (Barrhead), Limited.

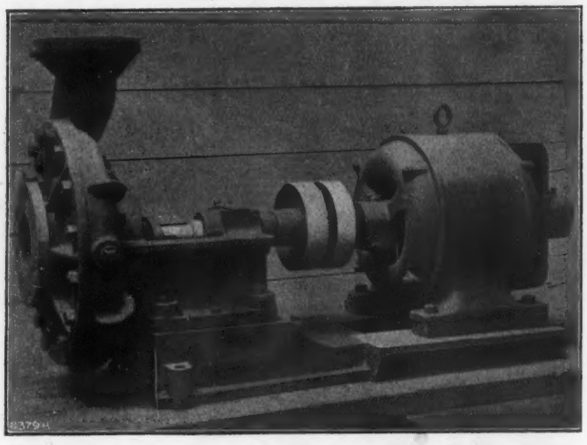


Fig. 5. High Lift Single Stage Pump.

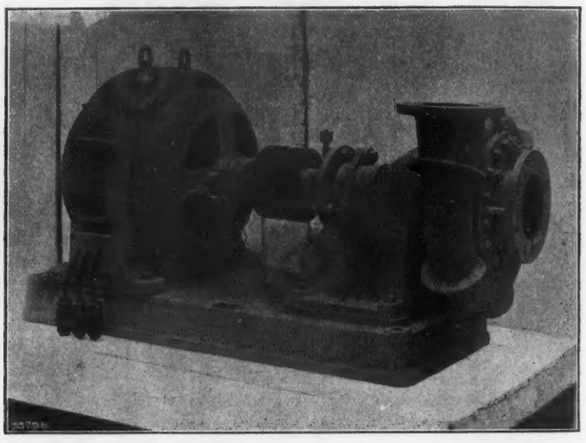
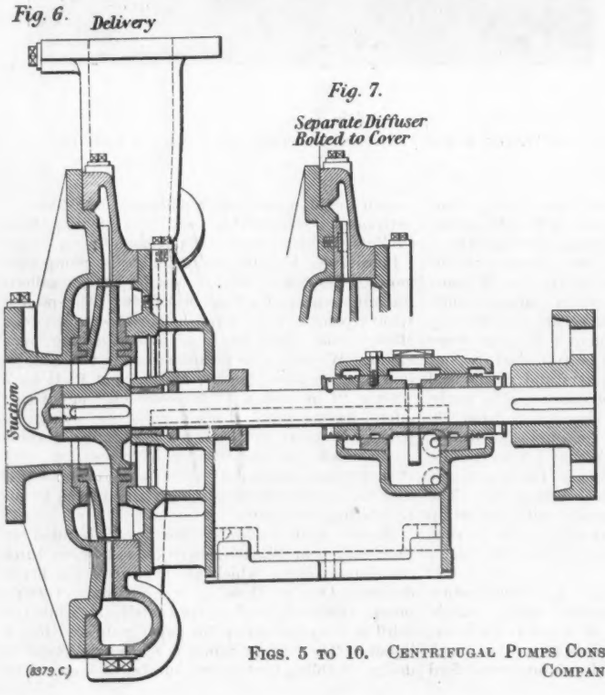
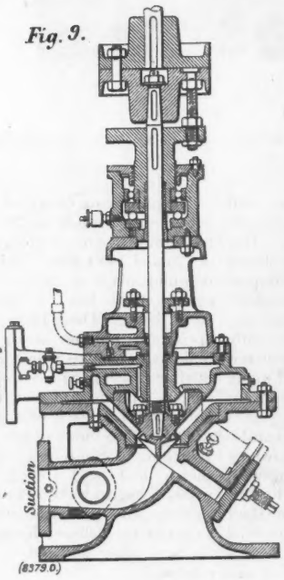


Fig. 8. Slurry Pump.





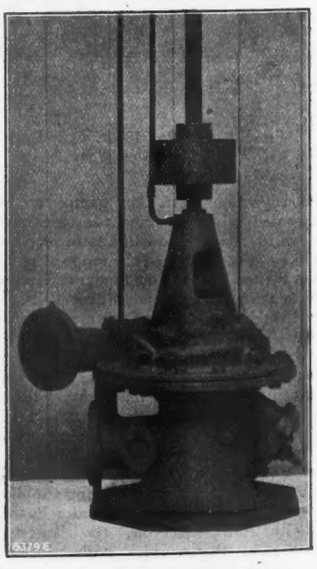


Fig. 10. Vertical Stereophagus Pump.

Figs. 5 to 10. Centrifugal Pumps Constructed by the Pulsometer Engineering Company, Limited.

RESTLER DOUBLE-ACTING PUMP AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. BECK AND CO., LIMITED, ENGINEERS, SOUTHWARK.

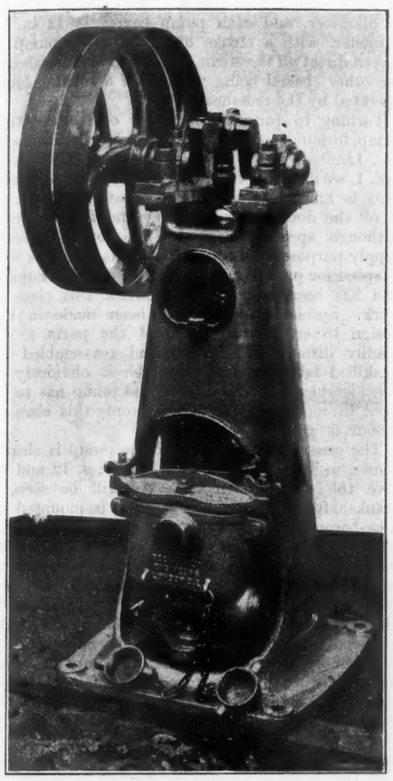


FIG. 11.

Fig.12.

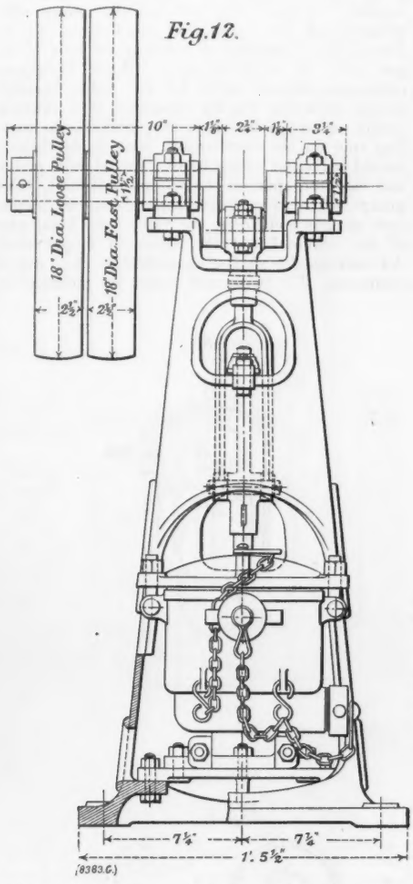
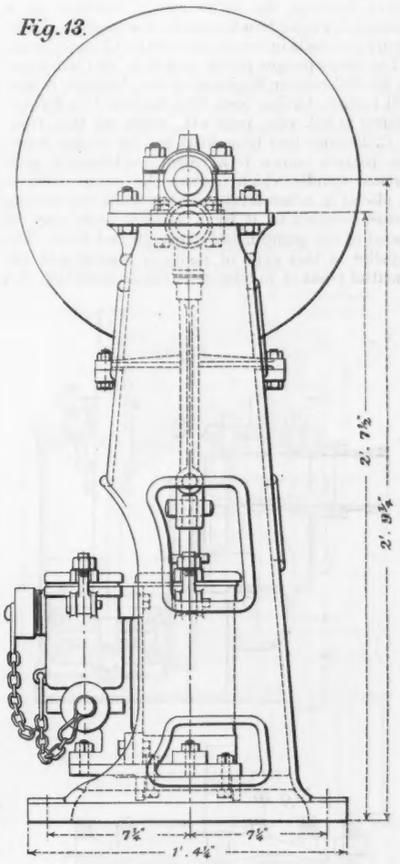


Fig.13.



combined in one unit, according to the lift required, the whole being held together by long bolts extending from cover to cover. The single-suction shrouded impellers are of phosphor bronze, and in addition to hydraulic end thrust balance, a ball thrust bearing is fitted to the outer bearing. This type of pump is now being fitted with roller bearings. The firm's high speed single stage centrifugal pattern of pump is illustrated in Fig. 3. The pump exhibited is driven direct by an electric motor. The pump is suitable for lifts up to 100 ft. It has a divided suction supplying both sides of the shrouded impeller. Hydraulic balancing of thrust is also embodied in the design. The pump is made with interchangeable covers on the sides, and may readily be used for drawing and discharging on one side or the other. A two-stage pump utilising what practically amount to two single-stage units of the above type combined, is also made by Messrs. Cochrane. These pumps will deal with heads of 300 ft. The second stage unit bolts direct to the first unit, but differs from the latter as regard the relative position of the feet and discharge. The discharge from the first stage is connected with the suction of the second stage by an external bend.

The small centrifugal shown in Fig. 4 is intended especially for use in paper mills, in connection with the pumping of paper pulp. It is, however, suitable for application in many other connections. The pump and impeller are in bronze. The characteristic feature is the impeller, which is virtually a starwheel with curved spokes faced on both sides and working in a machined close fitting casing. The fit of the impeller in the casing is such that the impeller sweeps the casing practically clear. Central suction is provided on one side only. The pumps are suitable for any heavy liquid not containing hard solids. In paper manufacture it is often necessary for pumps handling pulp to have to change over from one colour to another. With a pump sweeping the casing clear as is done in this type, very little flushing enables the change to be made without serious loss of time. The pump has ring-oiled bearings. The machine is also supplied driven by motor.

A large range of pumps is shown by the Pulsometer Engineering Co., Limited, of Reading. This includes many of the firm's well-known designs, with some more recent introductions. On the firm's stand are shown examples of Pulsometer steam pumps, as well as centrifugals of different patterns and for various uses. Thus, in addition to the ordinary low lift centrifugals, there are high lift pumps, pumps for slurry, for sugar handling, the ring type of pump recently described in ENGINEERING (see vol. cxv, page 217) and the vertical type of Stereophagus. Besides these there are exhibited small ice-making machines, vacuum pumps, flow indicators, and a rotary exhauster.

Some of these patterns are familiar to our readers. One of the high lift single impeller type of pump shown is illustrated in Figs. 5 to 7 herewith. This pump has a central suction, and the impeller is shrouded on both sides, discharging into a spiral through a narrow circular outlet fitted with diffuser vanes. From the section, Fig. 6, it will be seen that the spiral is developed altogether to one side of the vertical plane of the diffuser ring. The guide vanes are solid with or bolted to the cover. On each side of the impeller is a slip ring, the impeller being arranged with projecting rings fitting into the slip ring grooves. The pump bearing consists of a stuffing-box fitted with a gun-metal neck bush, cooled and lubricated by water under pressure, thus preventing the entrance of air when working under high suction lifts. In the event of the water being unsuitable for this, by reason of it being gritty, the passage can be plugged and an alternative passage employed for grease lubrication. The pulley bearing consists of cast-iron, white metal lined, bushes, ring lubricated from a large oil reservoir. Creeping of oil along the shaft is prevented by oil throwing rings.

These pumps are made in various sizes and lift up to 120 and 180 ft., running at moderate speeds. For instance, the B-type of pump exhibited, with 1½-in. delivery will pump 64 gallons per minute with 120 ft. lift, running at 2,400 r.p.m. An 8-in. delivery pump of the same type will pump at 120 ft. lift, 1,830 gallons per minute at 1,100 r.p.m. The L-type pump, working up to 180 ft. lifts only, runs about 200 r.p.m. faster. These figures are given for best efficiency. The deliveries can be greatly exceeded at higher speeds. The covers and casing are made to standards, and the delivery can be arranged in eight different positions round the casing to suit various piping arrangements. The same design lends itself well to a vertical spindle pattern, when the suction elbow is embodied in a short cast-iron base. In this case the pulley bearing is a ball bearing combined with a ball thrust bearing. The vertical type can be fitted in a frame of channel sections and arranged for being driven by electric motor for use in sinking operations.

The Pulsometer centrifugal slurry pump, illustrated in Fig. 8 is intended for use with water containing grit, such, for instance, as has to be dealt with in coal washing. In this pump the casing is made a good deal thicker than usual with the object of allowing for wear in the volute. The impeller is of hard cast-iron, of the single inlet type and shrouded on one side only. Radial vanes are arranged on the back of the impeller partially to counterbalance the end thrust. A feature of the pump is the renewable liner plate secured inside the cover by studs and nuts. This liner can be easily replaced when worn, while the impeller and shaft are given longitudinal adjustment so that the

impeller blades can be maintained close up to the liner. This adjustment is effected by means of screws at the thrust bearing, and by this means a high efficiency can be maintained in spite of wear. The spindle runs in a stuffing box and a double ball thrust bearing, the latter being mounted in a housing in which the adjustment is arranged. These pumps are made in several sizes up to 12-in. delivery.

The Stereophagus pump, which is also exhibited by the Pulsometer Engineering Co., Limited, is now well known, having been first described in ENGINEERING in vol. xciii, page 444, when the late Hon. R. C. Parsons first brought it out for sewage work. The pattern shown is a recent modification with vertical spindle which enables the pump itself to be placed in a low-level chamber while the driving motor, coupled to it by a vertical shaft, can be placed in the pump house above ground level. The impeller in this type of pump is conical and the essential point of the design is the introduction of a knife or cutter on the suction side of the casing, adjusted so as just to clear the impeller blades; any solid matter such as wood, cotton waste, bricks or debris being cut up into pieces small enough to pass through the pump. Being in this way self clearing it is suitable for unscreened sewage, trade effluents containing fibrous matter, or for bilge use on board ship. In the vertical pattern, shown in Figs. 9 and 10, the suction enters through an elbow in the base. The upper bearing of the shaft is fitted with ball race, and ball thrust. The stuffing box is arranged for water lubrication or grease.

The Pulsometer Company are also exhibiting, among other machines, a full-way pump, a two-stage pump for pumping sugar, and other interesting examples of their products. The full-way pump has an impeller of sufficient axial length to provide inside it an S shaped passage equal in cross-section to the suction orifice. Any solid capable of passing through the suction pipe is able to pass through the impeller to the delivery. Flexala and Resiline pumps for corrosive liquids are also exhibited. These have also been previously noticed in our columns (see ENGINEERING, vol. cxiii, page 74).

The exhibit of Messrs. A. G. Mumford, Limited, of Colchester, is confined mainly to reciprocating pumps. One of these is an electrically-driven vertical "duplex" oil fuel transfer pump with pump barrels 7 in. in diameter and a stroke of 8 in. This pump is capable of handling 50 tons of oil per hour. It is driven by a 12-h.p. Crompton continuous-current motor for 220 volts, through double reduction gearing consisting of a rawhide pinion on the motor shaft and machine-cut cast-iron spur on the countershaft, with double helical second reduction consisting of a forged steel pinion and cast-iron spur on the pump crankshaft. The pump end is of cast-iron throughout, with cast-iron buckets and liners, the valve seats being also of this material and the valves of forged steel. All bearings for shafts, countershafts, &c., are of gunmetal. The pump and motor are mounted on a common bed. Other types of vertical duplex pumps shown embrace a large and a small example of the firm's high-pressure feed pump, a brine-circulating pump, ballast pump, &c., while horizontal duplex pumps are also exhibited. A vertical direct-acting simplex oil fuel pressure pump is also shown by this firm. This has a cylinder 7½ in. diameter, pump cylinder of 4½ in. diameter, and a stroke of 9 in. The pump end is provided with a large air vessel with a Dewrance oil level gauge, and charging valve. A spring-loaded bye-pass valve with return connection to the suction side is also fitted, a hand wheel being provided for the ready adjustment of the pressure of oil to the burners. Two other simplex type pumps may be briefly noticed. One of these is a vertical high-pressure feed pump with steam cylinder 12½ in. in diameter, pump end 9½ in. in diameter, and stroke of 24 in. This is fitted with Messrs. Mumford's shuttle valve and gear. The pump has a continuous delivery capacity of 7,000 gallons per hour against high pressure. The valve gear is supported by three heavy steel columns. Adjustable bearings are fitted to all working parts. The steam piston rod is of steel and the pump rod of rolled naval brass, the two being connected by a split coupling of forged steel. The other exhibit to which we wish to refer is a vertical twin-barrel air pump driven by a simplex cylinder, similar to that of the foregoing feed pump. The cylinder is 8 in. in diameter, and each pump barrel is 12 in. in diameter, with a stroke of 12 in. One pump is driven direct off the steam piston rod and crosshead, the other barrel being worked off a rocking lever operated by the crosshead.

Fig. 14.

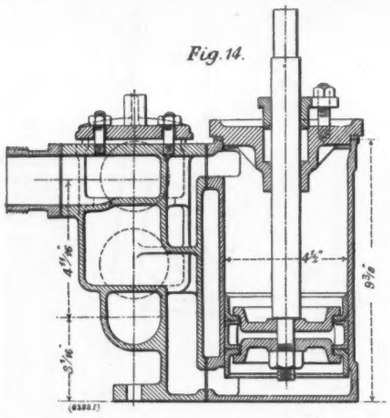


Fig. 15.

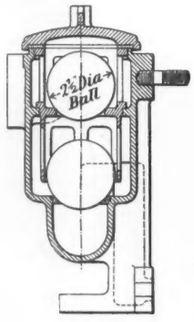


Fig. 16.

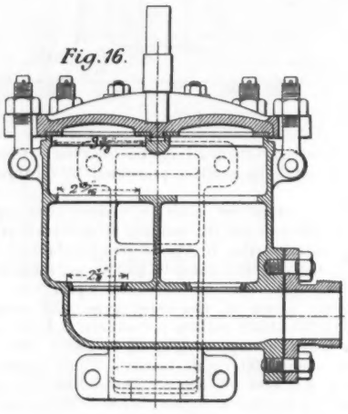
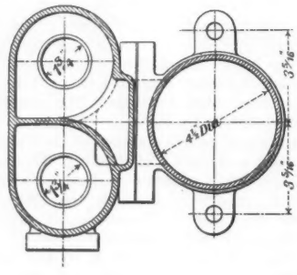


Fig. 17.



Turning to quite another type of reciprocating pump, forming part of the exhibit of Messrs. Beck and Co., Limited, 130, Great Suffolk-street, Southwark, S.E. 1, we illustrate this in Figs. 11 to 13 on page 691. This is known as the Restler patent pump; it is of the double-acting, lifting and forcing type. Although specially designed for domestic water supply purposes and for use on farms, &c., it is well adapted for pumping muddy water or thick liquids, and has been largely employed for this class of work. Special provision has been made in the design to enable the whole of the parts to be readily dismantled, cleaned and reassembled by unskilled labour, a feature which is obviously of considerable importance when the pump has to be used in remote localities where only this class of labour is available.

The general arrangement of the pump is clearly shown in Figs. 11 to 13, of which Figs. 12 and 13 give the main dimensions. As will be seen, a crankshaft, driven by belt pulleys, is mounted on a cast-iron pedestal to the base of which the pump barrel is attached by means of four bolts. By removing these bolts and withdrawing the cotter from the crosshead, the pump barrel and valve box can be easily removed, to enable the barrel to be cleaned or the cup leathers of the piston to be replaced. The top cover of the barrel is held in position by two hinged bolts, the nuts of which have only to be slackened off to enable the cover to be removed; the barrel, it should be mentioned, is 4½ in. in diameter internally and the piston stroke is 4 in. The valve box, which is shown in Figs. 14 to 17, is located outside the pedestal, and the cover is secured by hinged bolts similar to those employed on the barrel cover, but fitted, in this case, with wing nuts so that the cover can be removed without the use of any tools.

The arrangement of the valves and passages is clearly shown in the sectional drawings reproduced in Figs. 14 to 17. The suction and delivery valves are all similar, and each consists of a rubber ball weighted with a core of cast iron. Each pair of valves is contained in a cage which acts as a guide for both the suction and delivery valves, and also forms the seat for the delivery valve, as will be clear from Fig. 15. The two cages can be withdrawn when the cover has been removed, bringing the delivery valves with them and leaving the suction valves easily accessible in the bottom of the valve box. Screwed connections, having 2½-in. gas threads and fitted with removable covers, are provided on the valve box for the suction and delivery pipes. When running at 40 r.p.m. the pump, which weighs 2½ cwt., is capable of delivering 1,200 gallons per hour. A similar pump is also made for hand operation and was largely used during the war for trench pumping, and also in connection with mining operations. It is capable of raising 500 gallons per hour against a head of 20 ft. when worked by one man.

SCIENCE AT THE BRITISH EMPIRE EXHIBITION.—III.

IN the Palace of Engineering the Metallurgy Department of the National Physical Laboratory exhibits machines for testing chains and spur gears, fatigue (Wöhler type), and ball-thrust bearing friction, the last shown in operation.

The chain and spur gear testing machine measures the difference of torques on the driving and driven shafts and the actual torque on one of them. The details of the mechanism employed are sufficiently well known to make it unnecessary to explain them here. The torque difference is read by means of a tilting frame supported entirely on horizontal knife edges, and provided with a torque arm, scale

pan, pointer and dash pot. The torque on the driving shaft is measured on a small Hopkinson-Thring torsion meter. The accuracy with which the machine measures the efficiency of driving wheels is estimated to be within 0·1 per cent.

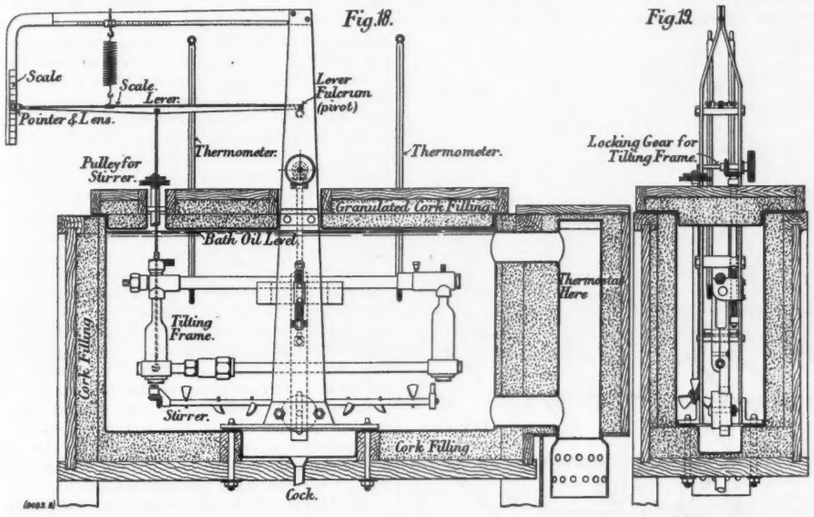
The fatigue measurement is made on a circular test piece, arranged in the machine as a cantilever and rotated at 2,200 r.p.m. The specimen is loaded at its free end with weights which are adjustable by equal increments, and carries a mirror at right angles to its axis. By a simple optical arrangement the slope of the mirror, and therefore of the test piece, is measured for each load, and the slope readings plotted against the applied load or the maximum fibre stress, have been found usually to give a straight line up to a limit at which a definite deviation from proportionality sets in, which for many materials happens at a point agreeing well with indications of distortion through fatigue stress.

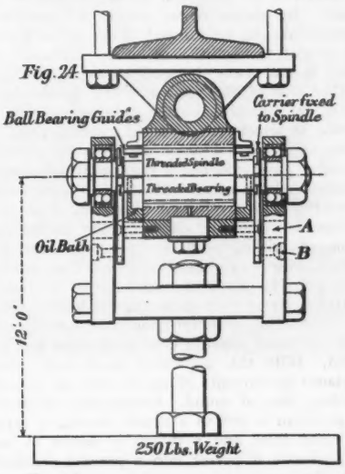
In the ball-thrust bearing machine, a 4-in. shaft is mounted in ball-bearing plummer blocks, and has its overhung end turned down to fit the bearing under test. The bearing is held in a spherical-seated frame, to which the load is applied through a lever system operating two links. The axial load is provided by a helical spring acting on an extension of the shaft, the reaction being taken by a large ball-thrust washer. The spring is calibrated for loads up to 1,600 lb. The friction torque is determined before, during and after a 100-hours' test, the direction of rotation being changed frequently, so as to obtain the mean of the torque in both directions. Temperatures are taken by a thermo-couple in the oil film on the ball race.

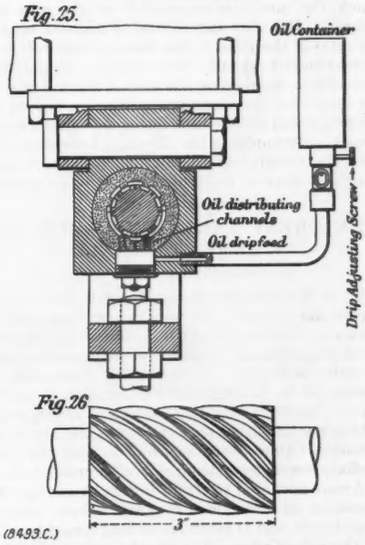
Among the Royal Society's exhibits in the Government Pavilion, the Laboratory shows apparatus for determining the kinematic viscosity of liquids under high pressures, coefficients of friction in boundary lubrication, pressure distribution on a hot journal, and head resistance of projectiles.

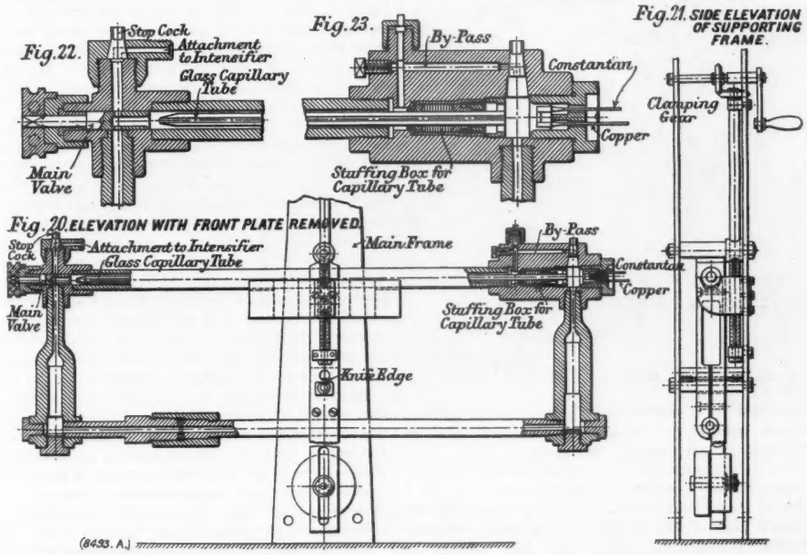
The apparatus for determining viscosity is the viscometer worked out and used on a series of oils by Mr. J. H. Hyde at the suggestion of Dr. T. E. Stanton. The complete apparatus is shown in Figs. 18 and 19, and enlarged views of parts are given in Figs. 20 to 23. It consists essentially of two horizontal tubes, the upper one of capillary dimensions, connected to each other by two vertical tubes. The tubular frame is supported by steel knife edges on agate plates carried in an aluminium frame, and the movement about this axis is controlled by a spiral spring. The lower half of this closed circuit is filled with mercury and the upper half with the liquid under test. The movement of the spring when extending is multiplied on a vertical scale by a lever carrying a pointer. The viscosity is calculated from its rate of flow under a given head of mercury, produced by tilting the frame after opening the cocks that control the movement of liquids within it, and closing them when the flow has ceased and a given head has been so secured. The vertical scale is adjusted so as to read zero when the pointer is horizontal before the frame is tilted, and the tension of the spring is so adjusted, by movement along a horizontal scale, that when the mercury head has formed and been secured between the cocks, the pointer, on being released, will again return to zero. The stiffness of the spring is so designed that its extension is proportional to the flow of the mercury head when the cocks are opened. This extension is measured by the movement of the pointer along the scale, and the viscosity of the liquid under test is determined by the rate of its flow so measured under the known head of mercury. The temperature is taken with a thermo-couple from a lagged oil bath in which the apparatus is immersed, the oil being kept stirred by a motor-driven agitator. To make sure that the apparatus is at the same temperature as the bath it is left for some hours with the bath at the desired temperature, which can be regulated to about 0·1 deg. C. By means of an intensifier the pressure in the viscometer is increased to various pressures up to about 10 tons per square inch. In this way the viscosity of oils is determined at definite temperatures and a variety of pressures, the viscosity rising with the pressure more or less rapidly according to the oil under experiment.

The apparatus for investigating lubrication is illustrated in Figs. 24 to 26. It is asserted that in some circumstances true lubrication may exist between surfaces that are separated not by a film of fluid, as in Osborne Reynold's application of hydrodynamical theory, but by a film having a thickness of the order of molecules. The present simple apparatus provides means that are claimed to yield true boundary lubrication, but this claim has been contested. The design was suggested by Sommerfeld's analysis of the hydrodynamical problem of maintaining a film of lubricant between









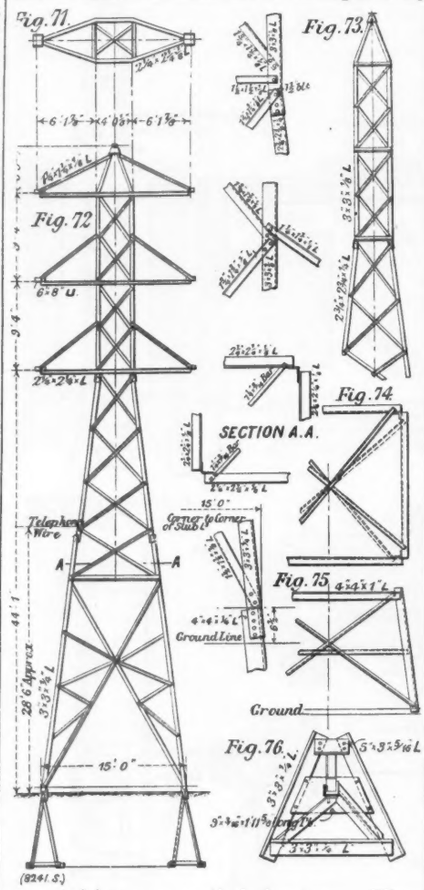
the surfaces of a journal and a half bearing, which indicated that the film would break down and the surfaces come into contact when the relative velocity of the surfaces fell to zero. Accordingly, the lubricating surfaces chosen for this apparatus are those of a rocking shaft and its bearing, the oscillations, with mean velocity of zero, being produced by a heavy pendulum swinging under gravity. To provide the condition found in uses such as worm gear, that each surface is covered with fresh lubricant before the next contact, the shaft and bearing are cut, respectively, with right- and left-handed spiral grooves of the same coarse pitch, so providing the bearing surface as a number of little islands standing in grooves that are kept filled with oil and are thus bound to be kept well lubricated before each contact. By means of set screws, the motion of the pendulum can be damped either by air friction alone or with the addition of bearing friction. The bearing is cut away beyond an angle of 45 deg. to either side of the vertical. The coefficients of friction are calculated from the curve showing the rate at which the oscillations disappear. A number of results obtained with the apparatus, it is claimed, gave evidence of the conditions assigned to boundary lubrication, but other explanations of the observations have been put forward. The results did show, however, the effect on the coefficient of friction of trifling additions to some lubricants. Another series of experiments showed that considerable—up to 22 per cent.—increase of friction resulted from one or both of the grooves being omitted.

An interesting diagram shows the apparatus by which the head resistance of projectiles has been studied. With this apparatus small scale models are placed in currents of air moving at velocities exceeding that of sound. Compressed air from a storage drum is led to a nozzle having a rapidly converging inlet and a diverging outlet of small angle, whence it passes into a parallel channel in which the model is suspended on the arm of a balance. Rayleigh determined a relation between the ratio of the Pitot to the static pressure of such a current and its velocity. Here the force on the model projectile is weighed on the arm of the balance; at the same time the static pressure in the current and the pressure of a Pitot tube facing the current are observed. By applying the Rayleigh formula to these data the velocity of the air and the coefficient of head resistance of the projectile can be determined.

THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.

(*Continued from page* 570.)

FROM Waddamana Power House to Risdon Substation near Hobart, there are two transmission lines shown on the map (Fig. 1 page 355 *ante*). The first of these crosses the Derwent at Bridgewater and is 65 miles in length. There are 589 galvanised steel towers, 68 ft. in height, and fitted with three cross arms. The first circuit, consisting of 7/·097 copper cables, was erected as part of the original 10,000 h.p. scheme. Cables were suspended from the intermediate towers by a string of five Thomas insulators, and were anchored to strain towers by strings of six insulators on each side of road and railway crossings, at all bends, and at intervals on long straights. Two of the cables were hung on the same side of the towers from the upper and lower arms respectively, and the third on the opposite side of the towers from the middle arm, the three conductors thus being spaced at the corners of a triangle. Later, a second circuit was added by suspending 7/·097 cables from the three vacant arms by strings of four insulators at intermediate towers and five at anchor towers, it having been found that more insulators were not necessary. The circuits were then re-arranged, so that the three conductors of either circuit are in a vertical line on the same side of the towers. The conductors are strung to a tension of 20,000 lbs. per square inch, and there is a minimum clearance above the ground of 20 ft., the average clearance being 25 ft. The conductors are spaced about 16 ft. 9 in. apart horizontally and 9 ft. 3 in. vertically. A ground wire consisting of one 7/12 S.W.G. galvanised steel cable is carried on the top of the towers. The standard pattern of tower is shown in Figs. 71 to 76, annexed. This actually shows a strain tower which differs but little from the ordinary suspension tower except as regards scantlings which, in the upper parts of the latter are rather lighter. The footings of the suspension towers are also simpler, the corner angle posts being continued into the ground and finished with a cast-iron plate slotted to slip up the leg and kept in place by cotters passing through the leg. In the strain towers, as shown in Figs. 71 and 76, the corner posts are finished with triangular anchors. Figs. 74 and 75 illustrate a standard 12 ft. extension for both types of tower, employed where the ground traversed made additional height desirable. At the Bridgewater Crossing of the River Derwent, there is a span of 1,180 ft., and, in order to provide sufficient clearance for small river steamers by a channel situated close to the eastern shore, a tower of 160 ft. high was erected on the eastern bank, the other end of the span being



supported by a comparatively low tower. Silicon bronze conductors having a sectional area of 0·169 sq. in. are used for this span.

No. 2 Transmission Line, which is 62¼ miles in length, follows practically the same route as No. 1 Line as far as Bridgewater, whence it runs along the eastern side of the Derwent to a point opposite Risdon Substation. There are 551 towers of similar type to those of No. 1 line, but painted instead of being galvanised. These towers were manufactured in Australia, most of the steel being obtained from Newcastle. There are two circuits, each of 20,000 h.p., consisting of 19/·083 copper conductors suspended by strings of four Jeffrey-Dewitt insulators. The spacing of the conductors is the same as for those of No. 1 Line. A typical view on No. 2 Line is given in Fig. 77, page 704. At Risdon, the River Derwent is crossed by a span 1,872 ft. in length, supported on the eastern shore by a tower 136 ft. 6 in. in height, the base of which stands on a cliff 281 ft. above high-water level, and on the western shore by a tower 171 ft. 6 in. in height, the base of which is 20 ft. above high water. A minimum clearance at mid-channel of 155 ft. above mean high water permits the passage of vessels of any size. The conductors used for this span consist of 37/·091 Copperweld stranded cable manufactured by the Copperclad Steel Company, U.S.A. Each strand consists of a steel core, which comprises 60 per cent. of the sectional area, the remaining 40 per cent. of the area consisting of a copper covering. A maximum tension of 3¼ tons per conductor was employed for stringing the cables. A view of this crossing as seen from the western shore is shown in Fig. 78, page 704.

No. 1 Transmission Line from Waddamana originally terminated at a sub-station at New Town, near Hobart. From this sub-station an 88,000-volt line, 14½ miles in length, was constructed to supply the Carbide Works of Electro-Products, Limited (formerly the Hydro-Electric Power and Metallurgical Company) at North West Bay. This consists of one circuit of 7/·097 cables supported on 200 timber towers, the material for steel towers being unobtainable, owing to war conditions at the time the line was erected. The three conductors are placed in a horizontal plane and spaced 12 ft. apart. Upon the extension of the scheme and the construction of the Risdon Substation, the original New Town Substation was converted into an outdoor switching station, enabling power to be supplied to Electrona from either circuit of No. 1 Waddamana-Risdon Line.

From Waddamana a third transmission line, 53 miles in length, supplies power to Launceston and district. There are 496 Australian-made steel towers, 52 ft. 6 in. in height. The strain towers are similar in design to those of the southern lines, but the intermediate towers are of a flexible type, and are designed to deflect sufficiently so as partly to relieve the strain resulting from a broken conductor. Each tower is fitted with two cross arms and the line carries one circuit of 10,000 h.p. capacity, consisting of 7/·097 cables suspended by strings of four Jeffrey-Dewitt insulators. The ground wire is carried on the top of the towers. Two of the conductors, spaced 14 ft. apart, are on the upper cross arm, and the third conductor on the lower arm, 9 ft., below the other two conductors.

An 11,000-volt transmission line, consisting of three 7/·097 conductors supported by pin type insulators on wooden poles, is now being erected from Bridgewater up the Derwent Valley to Plenty, a distance of 20 miles, and will supply the Township of New Norfolk, which at present derives a supply from an inadequate steam plant installed at the large Mental Diseases Hospital. Power will also be distributed from pole transformers, at 415 and 240 volts, to farms in the district, which comprises a rich area of orchards and hop grounds lying alongside both sides of the river, and a considerable demand from irrigation pumping plants will be made. This line is chiefly of interest as being the first extension of the hydro-electric system to rural centres. A similar extension from Electrona to the fruit-growing districts of the Huon River Valley is under consideration, and it is anticipated that the application of hydro-electric power to rural industries will gradually become general and result in marked advantages to the primary producers.

By reference to Fig. 1 (page 355 *ante*) it will be seen that Waddamana is situated almost exactly at the geographical centre of the Island, a radius of 100 miles from the power station embracing the whole of the State with the exception of the extreme north-eastern and north-western corners. The present scheme and its possible extensions can therefore supply power to any portion of the State.

On the Electrona Line, telephone wires are carried on the towers, but on the other 88,000-volt lines they are carried on separate poles some distance to one side of the main towers. Telephone boxes are installed at intervals for the use of the patrolmen, who inspect the lines twice weekly. On all sections of the line, which are not conveniently situated near a township, residences have been provided for the patrol men.

(*To be continued.*)

BRITISH EMPIRE EXHIBITION: MACHINE TOOLS.—II.

A FINE display of machine tools is to be seen on the stand of Sir W. G. Armstrong, Whitworth and Co., Limited, of 8, Great George Street, Westminster. The exhibits represent a selection of the standard manufactures of the company's works at

MACHINE TOOLS AT THE BRITISH EMPIRE EXHIBITION.

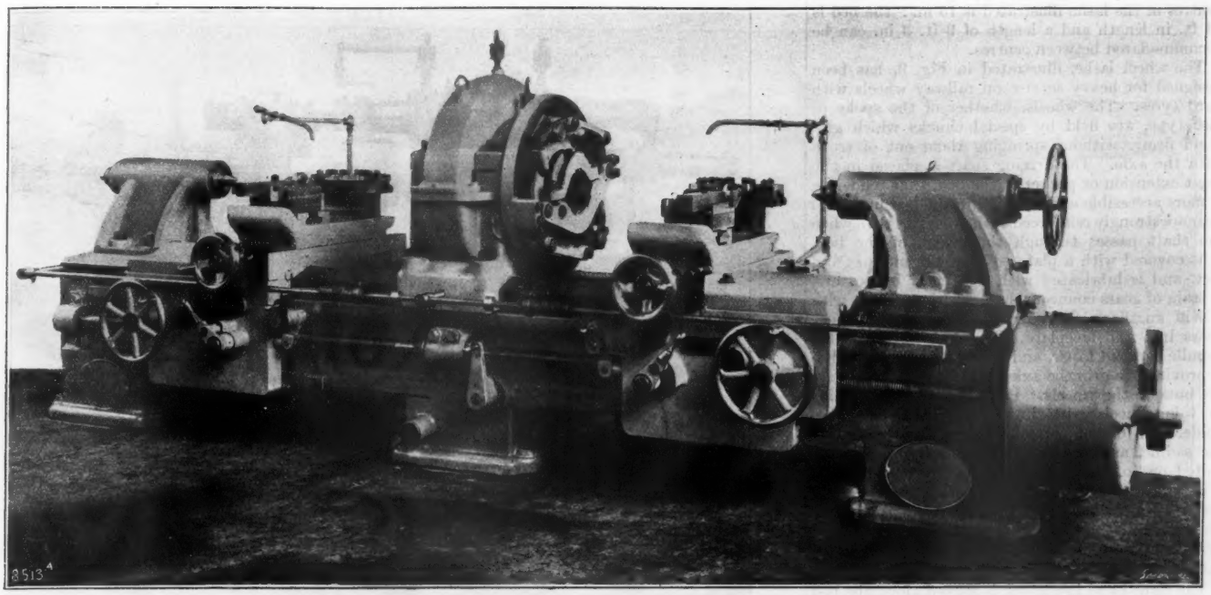


FIG. 8. AXLE-TURNING LATHE; MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED.

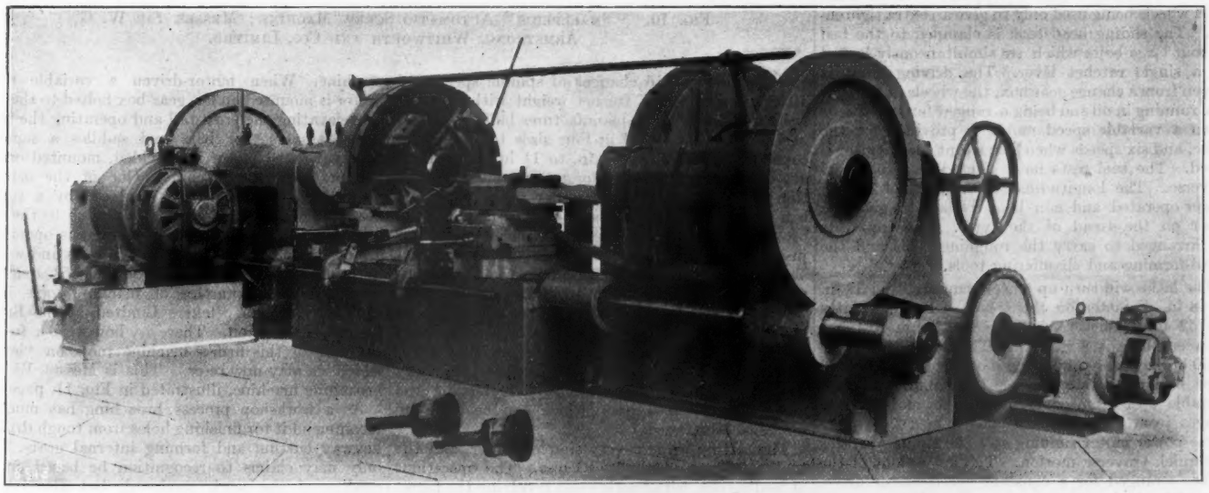


FIG. 9. WHEEL LATHE; MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED.

Openshaw, Manchester, and comprise a centrally driven lathe for turning the axles of railway carriages and wagons, a double-headed lathe for turning the wheels of the same vehicles, a vertical boring and turning mill, a "Smallpeice" automatic and other machines. The first two machines referred to are illustrated respectively in Figs. 8 and 9, above, and the automatic machine in Fig. 10, on page 696. The axle-turning lathe is designed for machining both ends of an axle simultaneously, and hence carries two independent saddles, one on each side of the central head, by means of which the axle is driven. The bed is of strong box section, with an abutment on the inner side of the front way to take the thrust of heavy cuts. The centre driving head is driven by a double-helical gear and pinion, running in oil, and attached to the right-hand side of the head is an "Andrew" compensating driving chuck, which is claimed as a considerable improvement upon the drivers with separate carriers usually fitted to machines of this type. By the use of the chuck referred to it has been found possible, under working conditions, to rough out the collars, journals, and wheel seats of three axles in a total time of 38 min. 10 sec. The journals were 9 in. long by 4¼ in. diameter. The axles were rough forgings, and the time stated includes taking the axles off the rack, putting them in the lathe, machining them, and replacing them on the rack.

The rigidity of the lathe and the strength of the chuck permit forming tools of the full width of the journals to be used without "chattering" taking place. The use of forming tools is recommended in certain cases even when they are being used for roughing only, as the fixed position of such tools longitudinally is an advantage in locating the journal. The front side of the tool rest is fitted with fixed tool-holders arranged to receive two separate circular cutters for the roughing cuts, and a holder is also provided on the front to receive a planishing roller. At the back of the rest forming-tools are mounted to finish the journals, and also to shape the "set-down" and the outer radius on the collar of the axle. With the lathe arranged for roughing only, an ordinary wagon axle with the middle part left black as usual, can be roughed out to within $\frac{1}{16}$ in. of finished sizes in 15 minutes floor to floor, this time being reduced to 10 minutes on test under favourable conditions.

The longitudinal power feed of the two carriages is obtained from a right and left-handed screw, from which by split nuts the carriages are automatically released when they make contact with set collars on a tappet rod along the front of the machine, thus making it possible to arrest the traverse at any given point. Quick adjustment for position is provided by rack and pinion gear and three power-feeds are obtainable from a gear-box at the end of the bed. Feed changing is accomplished by a lever situated at the centre of the machine. The tailstocks are movable along the bed, that on the right hand having the usual sleeve adjustment. Lubricant is supplied to the cutting tools by means of a pump, the necessary tank and fittings being conveniently arranged. The lathe can be driven either by belt, or by an electric motor. The drive

except when a variable speed motor is fitted, is through a four-speed gear-box. A friction-clutch operated by a lever at the centre of the machine controls the starting and stopping. The height of centres in the lathe illustrated is 15 in.; the bed is 14 ft. in length and a length of 9 ft. 3 in. can be accommodated between centres.

The wheel lathe, illustrated in Fig. 9, has been designed for heavy service on railway wheels with hard tyres. The wheels, whether of the spoke or disc type, are held by special chucks which grip them firmly without springing them out of truth with the axle. The driving shaft is placed in the front extension or pocket of the bed, thus rendering it more accessible and permitting the bed proper to be more strongly reinforced with cross ribs than when the shaft passes through the centre of the bed. It is covered with a plate to keep out cuttings and dirt, and is lubricated with sight feed lubricators. A train of gears connects the first driving shaft with a stiff auxiliary shaft carrying the pinion which gears into the faceplate. The nose of the lathe-spindle is bored taper, and a set of split cone bushes is provided to grip the axle journals when the latter are outside the wheels. Plain centres are supplied to take wheels with inside journals. The tool-holders are bolted permanently to the top rest of the saddle, and the tools are either inserted in, or bolted on to, the holders so that for regrinding it is only necessary to remove the small piece of high-speed steel which forms the actual tool. For roughing outs the tool is of cylindrical form, dropped into its place in the holder, and it retains its shape throughout its useful life.

The right-hand headstock is moved along the bed by screw and spare gear actuated by an auxiliary motor. A slipping clutch is provided which allows the spindle sleeves to slide up tight on the cone bushes on the axle without stopping the motors, the hand wheels being used only to give an extra tightening. The sliding headstock is clamped to the bed by four large bolts which are simultaneously locked by a single ratchet lever. The driving shaft is driven from a change gear box, the wheels in the gear box running in oil and being arranged for two speeds when a variable speed motor is provided for the lathe, and six speeds when a constant speed motor is fitted. The tool rests have a hand-operated cross traverse. The longitudinal traverse is, of course, power-operated and can be swivelled to give the taper on the tread of the tyres. The top rests are arranged to carry the roughing tools and the tread-forming and chamfering tools.

The lathe will turn up wheels ranging from 32 in. to 48 in. diameter on the treads. The faceplates are 52 in. diameter, and the maximum distance between them is 8 ft. 6 in. The driving motor is of 30 brake horse-power, and if of the constant speed type is arranged to run at 750 r.p.m. When a variable speed motor is fitted, the motor speed ranges from 300 r.p.m. to 900 r.p.m. A 5 brake horse-power motor running at 1,200 r.p.m. operates the quick traverse motion. The net weight of the lathe, arranged for a constant speed motor drive, but without electrical equipment, is 24½ tons.

Attached to the lathe is a rolling-in platform for the wheels, which is supplied as an extra. It provides a quick and convenient means for rolling wheels off the shop tracks direct into the lathe. The only adjustment necessary for the platform is to accommodate it to different sizes of axles, the slight alteration in height being effected by means of screws. The wheels when rolled up the inclined plane come opposite the lathe centres and, owing to the taper in the mandrel bushes, when the loose headstock is run up the pair of wheels is lifted clear of the platform. The device obviates the use of cranes or any overhead gear for mounting the wheels in the lathe. For the re-turning of wagon wheels the output is one pair in 18 minutes, floor to floor, but under favourable test conditions a pair of wheels can be completed in 15 minutes.

The "Smallpeice" automatic screw machine exhibited by Messrs. Armstrong, Whitworth and Co., Limited, is illustrated in Fig. 10. It has a collet capacity of $\frac{7}{8}$ in. diameter bar, but this can be increased to 1 in. diameter by the use of special tubes. It will turn to a maximum length of 3 in. The tunnet holes are 1 in. diameter, and

MACHINE TOOLS AT THE BRITISH EMPIRE EXHIBITION.

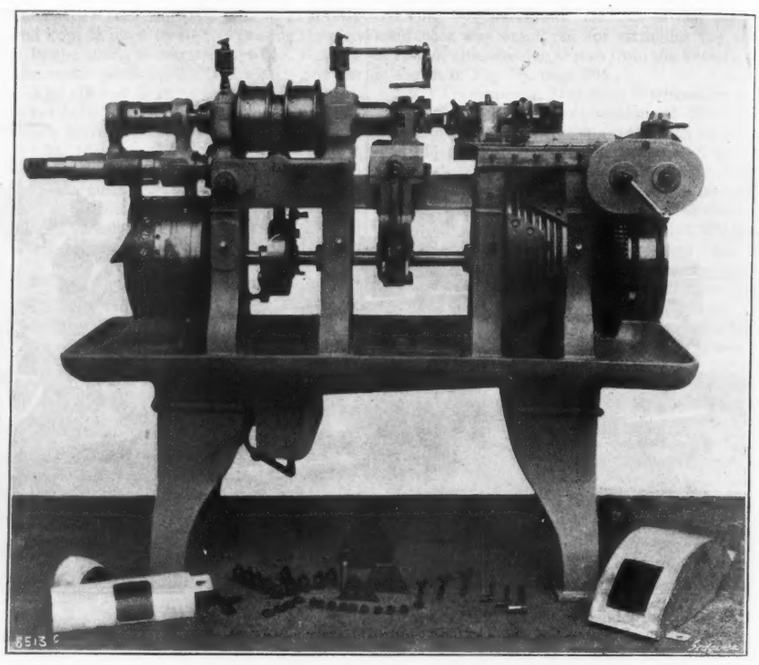


FIG. 10. "SMALLPEICE" AUTOMATIC SCREW MACHINE; MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED.

the machine has 16 changes of spindle speed and 10 changes of feed. Its net weight with counter-shaft is 18 cwts. The manufactures build machines of the type illustrated in four sizes to work with capacities ranging from $\frac{3}{8}$ in. to 1½ in. bar. They are designed particularly for the accurate production of large numbers of similar parts, but they can also be used economically for the manufacture of comparatively small quantities which would not justify the installation of more elaborate machines. The six-hole turret provides ample tooling accommodation for quite complex articles, while on simple work two articles can be made per revolution of the turret. In this manner two screws of different length, or a bolt and a nut may be produced alternately. When set up all operations are fully automatic, the only attention being feeding the machine with fresh bars, which can be done by unskilled labour.

The setting up is a very simple matter, and the tools used are of standard types. The operations of feeding out, withdrawing and revolving the turret are all performed at constant high speed, which is not affected by changes of spindle speed or feed, so that idle time is reduced to a minimum. The machines are constructed on rigid and straightforward lines, the workmanship and material being what would be expected from the reputation of the makers. All spindles are hardened and ground, all gears are of hardened steel, and all cams are adjustable and are provided with tenons which relieve their securing bolts of thrust. These features allow specially close timing of operations. A simple attachment can be provided to enable screws to be slotted without reducing the output of the machine.

Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, make vertical boring and turning mills of three nominal sizes, namely, 3 ft. 6 in., 4 ft. and 5 ft. The machine shown on their stand is the 4 ft. size, with a table diameter of 50 in. It will swing 51 in. between the uprights and has a height of 38 in. under the cross-rail. The travel of the turning and boring bars is 24 in. The table is driven by external spur-gear, the weight of the table can be eased from its track by an adjustable wedge operated by a ratchet lever in front of the machine. When motor-driven a variable speed motor is mounted on the gear-box bolted to the bed. For elevating the cross-rail and operating the rapid power traverse for bars and saddles a separate constant speed motor is provided, mounted on the top brace of the machine. One of the octagon boring and turning bars is replaced by a turret-head when desired, thus greatly adding to the convenience of the machine when numerous operations are desirable for one setting of the tools and work.

In our issue of April 25 (page 553 *ante*) we described two examples of machine tools being shown by Messrs. Vickers Limited, at the British Empire Exhibition. There is, however, a further example of this firm's machine tools on view to which we may now refer. This is Messrs. Vickers' broaching machine, illustrated in Fig. 11, page 697.

As a workshop process, broaching has much to recommend it for finishing holes from rough drilling, keyway cutting and forming internal gears. Not only may claims to recognition be based on the quality of the work produced, but also on the speed and simplicity of the operations. The machine of this type at work on the stand of Messrs. Vickers, Limited, in the Palace of Engineering, gives evidence of the qualities of design and construction to ensure easy and reliable working, which the firm have incorporated in their machine tools. Beside it are shown many fine examples of broaches for all classes of work, which are manufactured by Messrs. Vickers.

The machine has a body of box section, provided with ribs to ensure stiffness. All the gears and clutch motions are totally enclosed within this part of the structure. Accurately-machined guides are provided in the bed or trunk, which is also of the ribbed box form and is provided with an end plate of proportions suited to taking any special fixing used in the process. Underneath the end of the bed there is a tubular pedestal which carries an oil tray. The machine is of the screw type, the cutting and return movements of which are independently driven to permit a constant speed of return in combination with a variable speed of cutting. Both motions are controlled by the operator through a single lever. On the actual machine shown, which is known as the No. 3

MACHINE TOOLS AT THE BRITISH EMPIRE EXHIBITION.

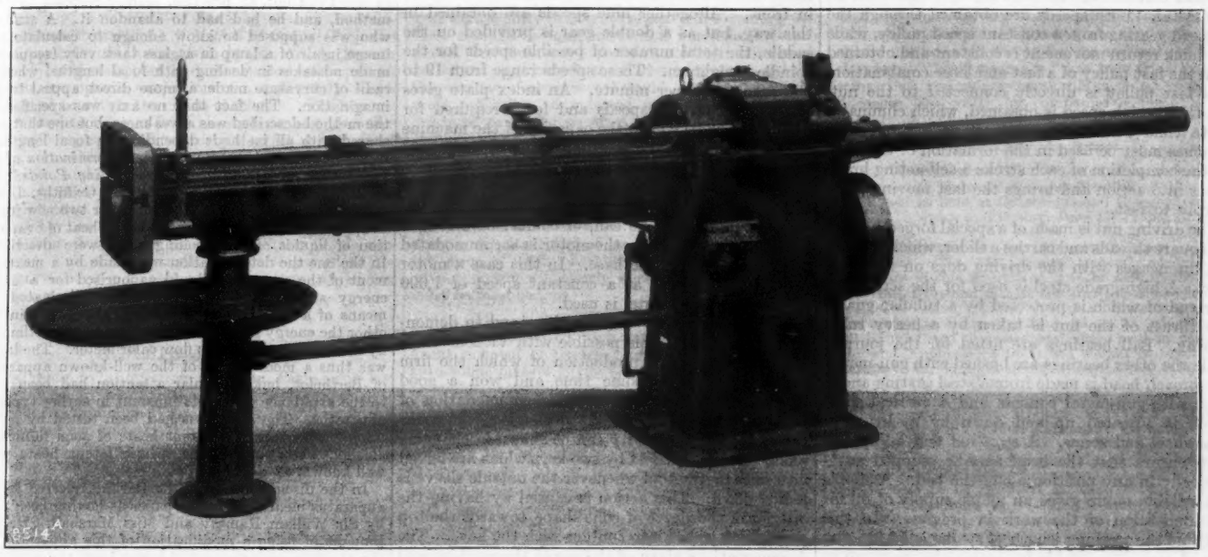


FIG. 11. BROACHING MACHINE; MESSRS. VICKERS LIMITED.

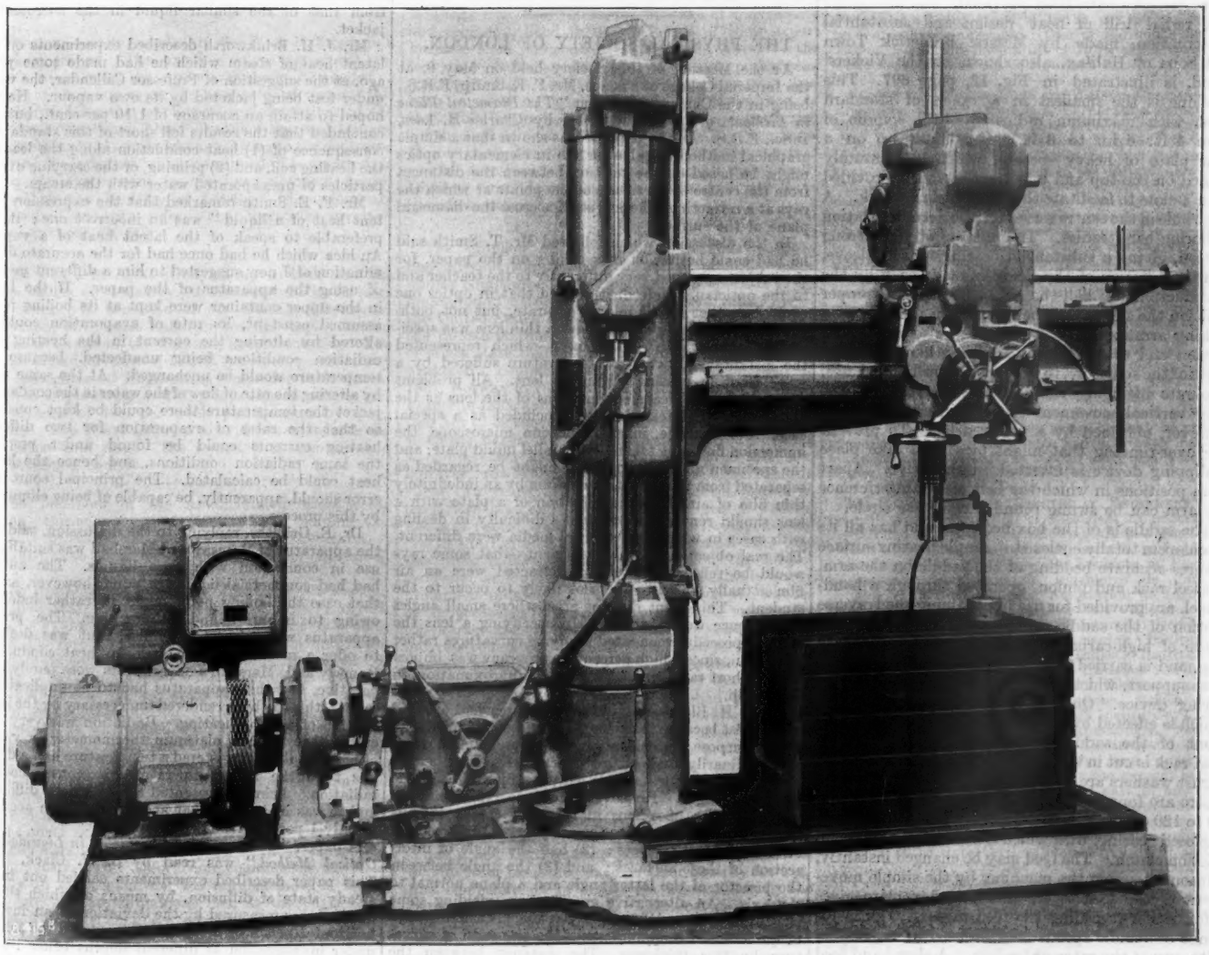


FIG. 12. RADIAL DRILLING MACHINE; MESSRS. FREDERICK TOWN AND SONS.

broaching machine, two cutting speeds of 3 ft. and 6 ft. per minute are arranged for, while the return is accomplished at a still higher speed. This machine is therefore suited to slow heavy cutting on hard material or fast working with light cuts on soft metal. Both speeds are obtained through the enclosed gearing from a constant speed pulley, while the quick return movement is constant and obtained from the fast pulley of a fast and loose combination. This fast pulley is directly connected to the nut, and thus a high speed is obtained, which eliminates waste time when a long travel or a number of broaches must be used in the formation of the hole. On the completion of each stroke a self-acting brake comes into action and brings the fast moving parts sharply to rest.

The driving nut is made of a special forged bronze, has square threads and carries a slider, which engages and disengages with the driving dogs on the large gear. A high-grade steel is used for the screw, the rear end of which is protected by a tubular guard. The thrust of the nut is taken by a heavy roller bearing. Ball bearings are fitted for the journal, while the other bearings are bushed with gun-metal. The broach head is made from a steel casting and is fitted with gun-metal runners and a vertical slide, which is adjusted up and down by means of a handwheel and screw. A stop rod and adjustable stops ensure that the head may be stopped automatically in any position along the bed. A simple and reliable pump gives an ample supply of oil for the lubrication of the work in progress. In this machine the working length of stroke is 54 in., and it is of capacity suitable for cutting keyways up to $1\frac{5}{8}$ in. width or cutting square holes of which the sides are not more than $3\frac{1}{4}$ in. For its operation a $7\frac{1}{2}$ h.p. motor is recommended. Machines of other sizes have been standardised, in which the same characteristics have been provided.

A radial drill of neat design and substantial construction, made by Messrs. Frederick Town and Sons of Halifax, also shown on the Vickers' stand, is illustrated in Fig. 12, page 697. This machine is the smallest in a range of standard sizes, with maximum radius of drill spindle of from 4 ft. 6 in. to 6 ft. It is built up on a base plate of heavy section, which is accurately planed on the top and underneath, and is provided with T-slots to facilitate the holding of the work. A large hole in the centre serves for the accommodation of boring bar steadies. The pillar is of very strong section, giving a substantial bearing for the sleeve, and the rotation of the sleeve is made easy by the introduction of ball bearings. When in proper position the sleeve may be retained in position by a locking arrangement. The arm is also of tubular section and of dimensions suitable, like the other parts of the structure, to resist heavy drilling stresses. Accurate fitting to the sleeve makes possible the easy vertical movement of the drill arm which is, however, obtained by a power drive. To prevent the over-running that might otherwise take place a slipping device is inserted on the drive. Apart from positions in which the belt causes interference the arm can be swung round a complete circle.

The saddle is of the box-bed form and has all its mechanism totally enclosed. Ample bearing surface ensures accurate bedding of the saddle on the arm. A steel rack and pinion, operated through a handwheel, are provided for use in obtaining the traverse motion of the saddle on the arm. The spindle is made of high-carbon high-tensile steel, ground to size, and is carried in a hard steel sleeve to give it firm support, which is balanced by a compensating spring device. Quick adjustment up and down, which is effected by means of the star handle on the front of the saddle, is therefore obtained. The feed rack is cut in the sleeve, at the bottom of which thrust washers are fitted to take the drilling thrusts. There are four rates of feed provided, ranging from 30 to 120 cuts per inch. They are obtained through enclosed gearing, with which is associated a powerful friction clutch. The feed may be changed instantly, without stopping the machine, by the simple movement of the feed lever, and an index plate gives information regarding the feed in use. The whole range of spindle speeds may be used in association with any of the rates of feeding. A slow hand feed is also obtainable through the hand-wheel at the foot of the saddle and a positive clutch mechanism, also on the saddle, enables the spindle to be started, stopped or reversed at will.

The gear-box contains gear wheels of high-carbon steel, of which the combination is changed by sliding them into and out of action by means of the levers in front. Altogether nine speeds are obtained in this way, but as a double gear is provided on the saddle, the total number of possible speeds for the spindle is eighteen. These speeds range from 19 to 500 revolutions per minute. An index plate gives information on the speeds and feeds required for each size of hole within the capacity of the machine and also indicates the position of the change-speed levers. Lubrication of the principal bearings is effected by the use of the syphon system, for which wells are provided which are easily accessible from outside. The machine can, of course, be arranged for direct driving, when the motor is accommodated on an extension of the base. In this case a motor of 10 h.p., running at a constant speed of 1,000 revolutions per minute, is used.

The drill is largely used on the stand to demonstrate the work that is possible with Vickers' drills and reamers, in the production of which the firm has specialised for some time and won a good reputation for them. For the accommodation of these tools a chuck of Vickers' design is used. With this, remarkable rapidity can be shown in changing tools. The tool is held by two keys which are forced into slots in the tool whenever the outside sleeve is pulled down. This action is caused by having the interior of the sleeve of cone shape towards the top part which comes into contact with the keys. The demonstrations given of the use of the machine and the small tools provides ample evidence, not only of the fields of service they are suited for, but also of the manner in which time wasting may be eliminated by their adoption.

THE PHYSICAL SOCIETY OF LONDON.

AT the Meeting of this Society held on May 9, at the Imperial College of Science, Mr. F. E. Smith, F.R.S., being in the Chair, a paper on "*The Diametral Plane in Elementary Optics*" was read by Charles H. Lees, D.Sc., F.R.S. In the paper it was shown that a simple graphical method suitable for use in elementary optics might be based on the relation between the distances from the centre of curvature of the points at which the rays at a refracting spherical surface cross the diametral plane of the surface.

In the discussion which followed Mr. T. Smith said he had some hesitation in speaking on the paper, for the subject appeared very differently to the teacher and to the optician. Indeed, it seemed that in optics one could be either intelligible or accurate, but not both. From the practical point of view, a thin lens was specified by one quantity—its power—which represented the instantaneous change of curvature suffered by a wave front in passing through a lens. All problems were capable of treatment in terms of the lens as the element if the thick plate was included as a special case. For instance, in an immersion microscope, the immersion fluid was taken as a parallel liquid plate, and the specimen under examination might be regarded as separated from the mounting medium by an indefinitely thin film of air. This combination of a plate with a lens should remove the student's difficulty in dealing with cases in which the external media were different. The real objection of this treatment—that some rays would be reflected instead of refracted were an air film actually present—was not likely to occur to the student. This point did not arise where small angles of incidence were involved. In specifying a lens the rational procedure consisted in giving curvatures rather than radii, since a high percentage accuracy was important in short radii, and a very rough approximation, in long radii.

Mr. T. H. Blakesley said that the paper had aroused his interest because the author had chosen lens elements for the purpose of specification which were different from those ordinarily used. Three geometrical elements were always required for a simple lens, of which at least one must be a length. He had been able to express numerous properties of a lens in terms of (1) the radius measured from the axis to the periphery, or intersection of the spherical surfaces; (2) half the angle of intersection of these surfaces; and (3) the angle between the bisector of the latter angle and a plane normal to the axis. An alternative specification, yielding some elegant formulæ, might employ as elements the thickness of the lens and the quotients of the two radii of curvature by this thickness. The distance between the two centres of curvature was also useful. He welcomed unconventional methods of specifying optical instruments because they frequently led to the discovery of neat analytical expressions.

The Author, in reply to the discussion, said that he had tried the use of curvature in teaching elementary optics, but students at the stage of knowledge he had in mind did not, in practice, readily respond to this method, and he had had to abandon it. A student who was supposed to know enough to calculate the image in air of a lamp in a glass tank very frequently made mistakes in dealing with focal lengths, whereas radii of curvature made a more direct appeal to his imagination. The fact that no axis was specified in the method described was a weakness, but one that was shared with all methods depending on focal length.

A paper on "*Apparatus for the Determination of the Latent Heats of Liquids of High Boiling Points*," by J. H. Awbery B.A., B.Sc., and Ezer Griffiths, D.Sc., was read by Mr. Awbery. In the paper two new forms of apparatus for determining the latent heat of evaporation of liquids of high boiling point were described. In the one the determination was made by a measurement of the amount of liquid vapourised for a given energy supply (radiation loss being eliminated by means of a constant temperature jacket), and in the other the energy given up on condensing was estimated by means of a continuous flow calorimeter. The latter was thus a modification of the well-known apparatus of Berthelot, but particular attention had been paid to the avoidance of defects inherent in earlier types of apparatus. The apparatus had been tested by determining with them the latent heats of such liquids as alcohol, water and aniline, whose latent heats were well known.

In the discussion, Mr. C. R. Darling referred to the apparatus mentioned in the paper as having been used by Sir William Ramsay and Miss Marshall. He had thought of using a modification of this apparatus for the absolute measurement of latent heat, the modification consisting in the use of a metal container for the liquid instead of a glass one, while the vapour would be led off by a side tube to a condenser. He had found that the temperature of the liquid under measurement would differ in such circumstances by only a degree from that of the similar liquid in the surrounding jacket.

Mr. J. H. Brinkworth described experiments on the latent heat of steam which he had made some years ago, at the suggestion of Professor Callendar, the water under test being jacketed by its own vapour. He had hoped to attain an accuracy of 1/10 per cent., but had concluded that the results fell short of this standard in consequence of (1) heat conduction along the leads of the heating coil, and (2) priming, or the carrying over of particles of unevaporated water with the steam.

Mr. F. E. Smith remarked that the expression "latent heat of a liquid" was an incorrect one; it was preferable to speak of the latent heat of a vapour. An idea which he had once had for the accurate determination of J now suggested to him a different method of using the apparatus of the paper. If the liquid in the upper container were kept at its boiling point, assumed constant, its rate of evaporation could be altered by altering the current in the heating coil, radiation conditions being unaffected, because the temperature would be unchanged. At the same time, by altering the rate of flow of the water in the condensing jacket the temperature there could be kept constant, so that the rates of evaporation for two different heating currents could be found under precisely the same radiation conditions, and hence the latent heat could be calculated. The principal sources of error should, apparently, be capable of being eliminated by this process.

Dr. E. Griffiths, replying to the discussion, said tha the apparatus of Ramsay and Marshall was suitable for use in connection with pure liquids. The authors had had commercial liquids in mind, however, and in that case the boiling point might be rather indefinite owing to impurity and to cracking. The present apparatus was somewhat similar, but was designed to offer a maximum resistance to heat conduction. Ramsay and Marshall's experiments were purely comparative, and their apparatus had to be duplicated in series; this has been rendered unnecessary by the introduction of electric heating. Radiation was very difficult to prevent: a platinum thermometer in vapour of boiling sulphur registered a temperature half a degree less than the true temperature, in consequence of radiation. Priming presented a very serious difficulty, and it was mainly on that account that an accuracy of only 1 per cent. was claimed.

A paper, "*On the Study of Diffusion in Liquids by an Optical Method*," was read by B. W. Clack, Ph.D. This paper described experiments carried out in the steady state of diffusion, by means of which the coefficient was measured by the deviation of an incident horizontal pencil of light, which traversed the solution under investigation at different depths below its surface. The concentration of the solution varied with the depth from zero to complete saturation, but was

constant with the time, and the accuracy in measurement was increased by the employment of interference fringes. The coefficient of diffusion, in certain cases, was found to pass through a minimum value, in accordance with the expectations of Arrhenius, increasing for more dilute solutions towards Nernst's theoretical limit.

A demonstration of a "*Method of Optical Projection of Opaque Objects*" was given by Mr. W. A. Benton. The object of the apparatus demonstrated was to provide means for opaque projection of a sufficiently simple design to be within the means of schools. The lens was calculated to have as wide an angle as possible, other merits being sacrificed to this one so far as was necessary. In the result very strong illumination was obtained, and chromatic and spherical aberration were not noticeable in the conditions for which the device was intended. The object to be projected was illuminated by two gas-filled incandescent lamps, and the light from it fell on a specially designed simple condensing lens of wide angle, whence it passed to the screen through a lens of smaller aperture which was chromatically over-corrected.

INDUSTRIAL NOTES.

In reply to a question asked in Parliament last Monday as to whether the Government proposed to introduce a Minimum Wage Amendment Bill applicable to the mining industry, Mr. Clynes said he had every hope that a settlement of the present dispute in the coal mining industry would be reached without further intervention on the part of the Government.

The joint sub-committee of coalowners and miners met at the offices of the Mining Association last week-end, to deal with detail points of the proposed new wages agreement, referred to in our preceding issue, the terms of which were put before a delegate conference of the Miners' Federation held yesterday in London. A number of district miners' associations have instructed their delegates to vote in favour of the new terms. Others, however, including Scotland and South Wales, have declared against acceptance.

The wool textile industry in the West Riding is in a state of unrest. The existing wages agreement expiring to-morrow, the operatives have demanded a 10 per cent. advance on the base rates of wages; this was refused by the employers' representatives of the National Wool and Allied Textile Industrial Council at a meeting held a fortnight ago, owing to the depressed state of the industry, which continued, it is reported, in spite of improvement in the unemployment figures issued by the Ministry of Labour. Discussions are proceeding on both sides. The operatives involved number about 200,000.

The Board of Arbitration, set up to look into the wage claims of the shipyard workers, held its sittings last week. It consisted of Sir William Mackenzie, chairman, Mr. James Fullerton for the employers and Mr. A. G. Cameron, the workmen's representative. The claims are an advance of 17*s.*6*d.* per week, presented by the Amalgamated Engineering Union for their Southampton shipbuilding and ship-repairing members, and an advance of 10*s.* per week put forward by other unions. The Board listened to evidence from both the employers and men. The award, it is announced, is to be issued shortly.

The members of the Amalgamated Engineering Union throughout the country are claiming an advance in wages of 20*s.* per week. The claim, it is added, is to come before the employers on June 5.

The Iron Trades Employers' Insurance Association, Limited, 82, Victoria Street, Westminster, S.W.2, held its annual general meeting on the 8th inst., when the directors submitted their report and statement of accounts for the year ending December 31, 1923. The premium income for the year was 454,069*l.*, an improvement on the 413,835*l.* for 1922, but much below the 696,644*l.* of 1921. All the British insurance companies, it was added, had experienced the same depreciation in their workmen's compensation business. During the year under review, the amount paid and provided in respect of compensation and incidental expenses was 430,461*l.* There remained a balance on revenue account of 106,861*l.* A motion to the effect that 15 per cent. of the premiums paid by the members in 1923 be returned to them was passed unanimously. The Association commenced the year 1923 with 2,045 members, the number now is 2,133. The directors are prominent men in the engineering world, whilst the members represent all the best-known firms in metallurgy, engineering and shipbuilding.

Speaking at the annual general meeting of Messrs. Sir W. G. Armstrong, Whitworth, & Co., Limited, held last Friday, at Newcastle-on-Tyne, the Chairman of the Company, Sir Glynn H. West, said that if it had not been for the trouble in the shipyards and the possibility of further disputes in the engineering and coal industries, he could have felt fairly confident in saying that the Company's prospects for the present year were slightly in advance of last year's results; with these troubles in sight, however, it was difficult to prophesy. One could only hope that an understanding would be arrived at quickly in the trades referred to, and that the serious consequences would be avoided which must otherwise be reflected in the year's working. "I have explained so often the disastrous results of stoppages, not only to ourselves, but also to the industry of the whole country," added Sir Glynn, "that it is unnecessary to dwell again upon this, but it must be remembered that the present additional activity in all our departments is entirely the result of contracts taken at fixed prices, with a very small margin of profit, and if wages are increased and if the price of coal, on which we depend so much, is advanced, you will clearly understand that the effect must be most serious."

The abolition of the McKenna duties and the consequent removal of Canada's preference in the British automobile market is viewed with great concern in the Dominion, according to *Canadian Machinery*. Since April, 1919, Canadian cars have entered Great Britain under a preference of one-third of the duty imposed on foreign imported cars, in other words, they were admitted at 22⅔ per cent. as against a general tariff of 33⅓ per cent. Mr. G. McLaughlin, of the McLaughlin Motor Car Co., Oshawa, has stated that the new measure will affect every Canadian business operating under the McKenna tariff preference, and will work out seriously to the disadvantage of Canada. "We hear a great deal of talk," he added, "about the Mother Country, but when it comes to matters of fiscal policy, there does not appear to be much mothering about it of late. If the industry is dealt such a blow as that, the workers cannot help but suffer at the same time." Mr. T. A. Russell, of the Willys-Overland Company, said that American plants, for the sake of convenience and economy, liked to do the whole of their export business from one centre. In the past, owing to the fact that Canadian branches could get preferential treatment from Great Britain, the inclination had been to allow a big share of the export business to that land, as well as to other counties, to be carried out through Canada. That gave work to the Canadians. If now there is nothing to be gained in following that course, American plants will carry on all their export business direct from American works, and will leave Canada to get on as best she can.

The problem of determining methods whereby underground compensation insurance rates for metal mining companies can be equalised in proportion to the underground hazards involved has been taken up by the United States Department of the Interior, through the Bureau of Mines. In their Serial 2590, the Bureau of Mines state that Germany in 1884 enacted the first workmen's compensation law. Austria followed in 1887, Norway in 1894, Great Britain in 1897*, Italy and France in 1898, and Spain in 1900. The first compensation Act to be enacted in the United States was in 1902, when the Maryland Legislature passed an Act providing a co-operative accident insurance fund; this law, however, was declared unconstitutional after being in effect two years. In 1908, Massachusetts passed an ineffective law, and during the same year a Federal Act was passed which was the first real compensation law in the United States. It was not until 1911 that the larger industrial States began taking the subject seriously, and at the present time practically every prominent industrial State has recognised the virtues of compensation for accidents to industrial workers by the passage and enforcement of effective statutes. The progressiveness of American private corporations was demonstrated, however, by the fact that several years before the States considered compulsory compensation measures, many large employers, as had been done here, made provisions to lessen the workmen's losses through accidents. These measures often consisted only of hospital treatment, but some provided compensation for permanent disability or death. Some of the larger corporations grouped themselves together to provide certain protection to injured employees. Through the enactment of these employer's liability laws, metal-mining companies have been compelled to add a new item to their cost sheets, in the form of premiums for insurance to cover their liability for lost-time compensation of employees injured during the course of their employment. This cost is a variable in the different States and with different mines, due not only to different laws, and assumed and computed rates, but to varied mining practices. The cost of insurance on the ton mined or pound of metal produced is considerable, and many operators believe that a much fairer and more moderate rate of insurance could be established and still leave a profit for the companies assuming the risk, if an intelligent study of mining practices and hazards were made. They feel that the mine having comparatively few accidents, through intelligent methods of accident prevention, should not be taxed to pay for the accidents occurring elsewhere. "Self-insurance" has been tried by many companies, and as a general rule is found to be considerably less costly by companies sufficiently large to continue it over a term of years.

* Britain passed in 1880 the Employers' Liability Act.

THE INSTITUTION OF WATER ENGINEERS.—The Twenty-ninth Summer General Meeting of this Institution will be held at Coatbridge and Glasgow on Wednesday, Thursday and Friday, June 11, 12 and 13.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—The 51st annual general meeting and conference of this Institution is to be held in the North End Hall, Croydon, and at the Institution of Electrical Engineers, Savoy place, Victoria Embankment, on Wednesday to Saturday, June 25 to 28, when papers will be read and discussed and visits paid to places of interest. Applications to attend should be sent to the Secretary, 92, Victoria-street, Westminster, S.W.1, not later than the 31st inst.

CONTRACTS.—Messrs. Hollings and Guest, Limited, Birmingham, state that in addition to the heavy sludge pump supplied by them last year to the Birmingham Tame and Rea District Drainage Board, they have now received a further order for a similar set of hydraulic pumps, also to be installed at their Saltley Drainage Works. The pump is of the 3-throw single-acting piston type, having three pistons, and capable of pumping 500 gallons of sewage sludge per minute when delivering, and 1,000 gallons of sludge per minute when circulating.—The Engine Works Department of Sir W. G. Armstrong Whitworth and Company, Limited, have secured an important contract from the Great Western Railway Company for the supply and erection of five large fixed coaling hoists. Two are destined for the Port Talbot Docks, two for Barry Docks, and one for Newport Dock. They will each be capable of handling a gross load of 30 tons at a lifting speed of 180 ft. per minute and will be hydraulically operated. One of the hoists for Port Talbot Dock will have a lift of 70 ft. above quay level while the remainder are 60 ft. hoists.

PERSONAL.—Messrs. Dodd and Watson, Chartered Civil Engineers, County Chambers, Corporation Street, Birmingham, state that they have been joined in partnership by Mr. John D. Watson, Member of Council of the Institution of Civil Engineers, who has resigned his position of Chief Engineer to the Birmingham Tame and Rea District Drainage Board to devote his whole time to private practice.—Mr. John Dykes is to be appointed as from June 30, the principal surveyor at Liverpool for Lloyd's Register of Shipping, in succession to Mr. A. Campbell Holmes, who is retiring from that position.—Mr. F. G. Ketelbey, A.M.I.E.E., who for 12¼ years was connected with the B.T.H. Company, Rugby and Birmingham, has now relinquished his position as Midland branch manager of the E.A. Company, and opened offices at Worcester Chambers, 14, New-street, Birmingham, where he will trade in his own name as chartered electrical engineer and mechanical engineer.—Messrs. Dowding and Dickinson, machine tool merchants, Windsor House, Victoria Street, London, S.W. 1, have engaged as from June 1 the services of Mr. Wilfred M. Pudge who has for the last eleven years been with Messrs. George Kent, Limited, Luton, where he held the position of works engineer. Mr. Pudge had previously been for many years with Messrs. D. Napier and Sons, Acton and Messrs. W. M. Still, Hatton Garden.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The Council of the Institution of Electrical Engineers have invited delegates from the following kindred institutions abroad to visit this country as the guests of the Institution from July 10 to 15: American Institute of Electrical Engineers; Asociación de Ingenieros de Caminos, Canales y Puertos, Madrid; Asociación de Ingenieros Industriales, Madrid; Associazione Elettrotecnica, Italiana; Dansk Ingenirforening, Denmark; Den Norske Ingenirforening, Norway; Engineering Institute of Canada; Institute of Engineers (India); Institution of Engineers, Australia; Koninklijk Instituut van Ingenieurs, Holland; Schweizerischer Elektrotechnischer Verein; Société Belge des Electriciens; Société Française des Electriciens; South African Institute of Electrical Engineers; Svenska Tecnologforeningen, Sweden; Vereeniging van Directeuren van Electricitatsbedrijven in Nederland. On account of the large number of delegates it will not be possible for the general body of members of the Institution to take part to any great extent in the functions arranged for the entertainment of the visitors, but Members, Associate Members and Associates will be given the opportunity of attending the luncheon at the Hotel Cecil on Thursday, July 10, and the Kelvin Centenary Banquet at the Connaught Rooms on Friday, July 11, when Lord Balfour will take the chair. The reception of the delegates by the President, Dr. Alexander Russell will take place at the Institution Building at 12.30 p.m., on July 10. From July 11 to July 15 visits will be paid to the British Empire Exhibition, as well as to Cambridge, Birmingham, Stratford-on-Avon, and the Underground Railway repair shops at Chiswick and Windsor.

TAR MACADAM PLANT WITH SCROLL DRIER AND CUBE MIXER.

AT the Public Works, Roads and Transport Exhibition held last October at the Agricultural Hall, one of the interesting working demonstration plants represented the tar and bitumenised macadam preparing plant of Mr. J. F. Wake, of Darlington. This plant is the outcome of practical experience in the preparation and supply of macadam of this class, the output of which from the Port Clarence Works of Messrs. Wake and Co., Limited, near Middlesboro', has amounted in the past two years to over 200,000 tons, while large orders are now on hand for public authorities and others all over the country. At the Port Clarence plant Messrs. Wake and Co. are working on a large slag heap from which their aggregate is procured. This heap is shown in Fig. 1, the view giving some idea of the quantity of material available. The heap is about 140 ft. high and varies in age from 35 to 70 years, and having been accumulated when Cleveland ores and carboniferous limestone were used exclusively, is of much harder and denser slag than is now produced with mixed ores. This hard slag weathers well and is less porous than modern slags, and is well known as an excellent material for road-making purposes under modern conditions.

The Port Clarence works consist of a slag-breaking plant of which an illustration is given in Fig. 2, and of the tar macadam plant shown in the view in Fig. 3. The slag-breaking plant has a capacity of 800 tons of broken slag per day, while the output of the tar macadam plant is 500 tons of tarred and bitumenised macadam per day. The difference is due to the demand for untreated broken slag.

So far as we are at present concerned the greatest interest lies in the tar macadam part of the plant, the general arrangement of this being shown in Figs. 4 to 6, on page 701. The plant is very complete, all handling being done by machinery. It is worked by electric motor shown in the plan, Fig. 5, driving by belt a main shaft from which the other drives are taken. The plant is served by railway tracks on either side of it, one being for the wagons of new slag coming from the breaker plant, while the prepared and finished material is dumped direct into wagons standing on the other side of the plant. The broken slag is conveyed from the breaker plant in 12-ton hopper wagons, the load being dumped into a hopper below ground shown at A, Figs. 4 to 6. This hopper delivers by a gate-controlled side chute into the boot of an inclined bucket elevator, driven by belt off the main shaft. This elevator delivers as shown in Fig. 4 into a chute C leading the material to the drier D, which is one of the special features of Mr. J. F. Wake's system. This part of the installation is shown in greater detail in Figs. 7 and 8, on page 701. The drier is, we believe, quite unique and possesses a good many advantages over the usual long inclined drum. It will be seen to be very compact, but in spite of this the material is passed over a distance of about 200 ft. all the while in a heated atmosphere.

The drier consists of a revolving scroll or spiral, into the centre of which the broken material is fed, to be worked gradually towards the outer coils, finally being discharged into an enclosed hopper H below. The spiral is built on a spider which on one side is fitted with a boss into which is keyed a short shaft carried in a bearing. Close to the latter is arranged a worm wheel fixed to the shaft, and driven by a worm. The latter is on a shaft which in Fig. 5 will be seen to be driven by belt from the main shaft. On the opposite side the drier centre is provided with a large conical mouth through which passes the chute from the feed hopper. The conical mouth is provided with a stiff flange, and this is supported by two flanged anti-friction rollers 24 in. in diameter. The whole of the scroll or spiral is enclosed in an insulated steel casing and a good sliding fit is arranged round the centre casting on each side. Hot air is fed to the inside of the drier from a furnace close alongside. The hot gases are drawn through the scroll and out through the feeding chute, which is connected by a large duct with an exhaust fan. The position of the fan G is clearly shown in Figs. 4 and 5, while the exhaust duct will be easily recognised in all three illustrations, Figs. 4 to 6.

Among the advantages which this form of drier possesses, it may be pointed out that the material is gradually and uniformly heated, leaving the scroll at the hottest part. The heat in the gases is well utilised, the gases flowing through the drier in a stream of small cross-section in intimate contact with the broken slag and hot sheet iron forming the scroll. Radiation losses can be greatly reduced as compared with the long drum type of drier. First cost is moderate and the structure is compact and simple. The power required to drive it is low compared with the long inclined drum type. The scroll construction results in greatly decreased disintegration of the aggregate as compared with cascading driers, and the clean fractures and angularity of the metal are retained, with subsequent advantage in use, while relatively little dust is produced. The wear of the scroll is almost negligible, plates ¾-in. thick showing practically no deterioration after the passing through the machine of over 45,000 tons of hard broken slag.

The furnace E is supplied with air by a fan F working at about 10-in. water gauge pressure. Arrangements are made so that the heat of the flue gases can be varied between 400 deg. F. and 2,000 deg. F., this variation being obtainable in a few minutes. In practice temperatures between 750 deg. F. and

TAR MACADAM PLANT AT PORT CLARENCE.

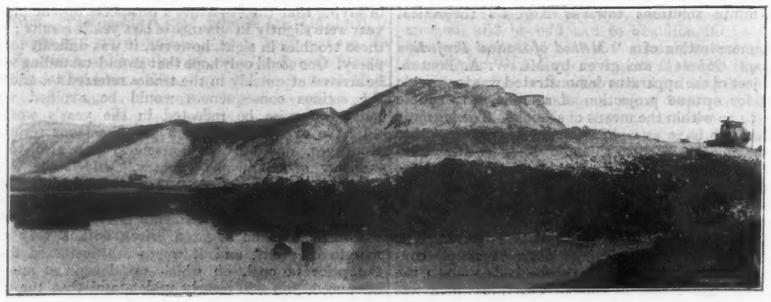


FIG. 1. SLAG HEAP AT PORT CLARENCE WORKS.

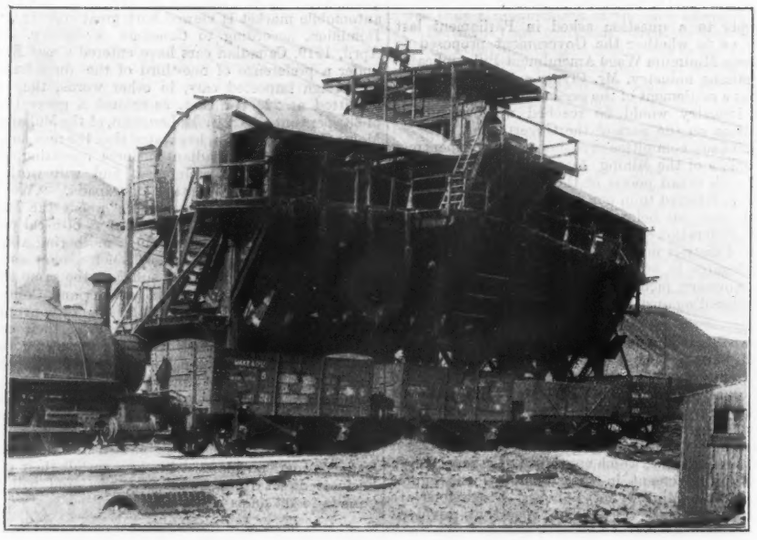


FIG. 2. THE SLAG-BREAKING PLANT.

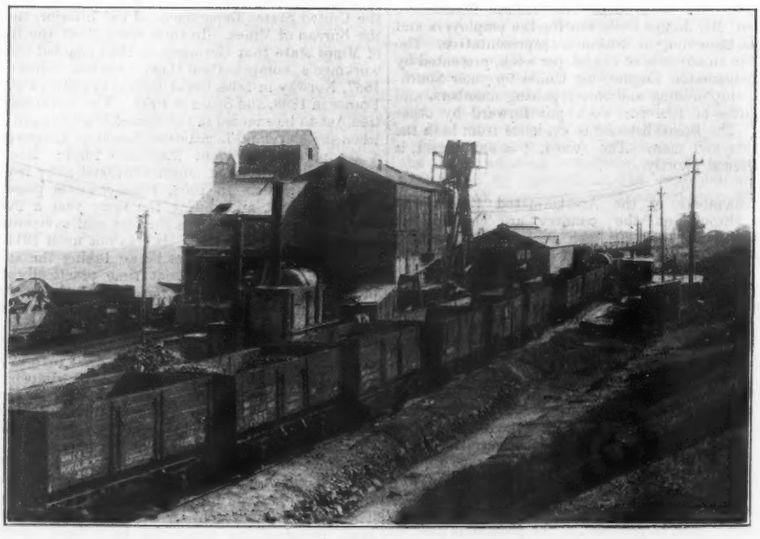


FIG. 3. THE TAR MACADAM PLANT.

MACHINERY AT THE PORT CLARENCE TAR MACADAM PLANT.

CONSTRUCTED BY MR. J. F. WAKE, ENGINEER, DARLINGTON.

Fig. 4.

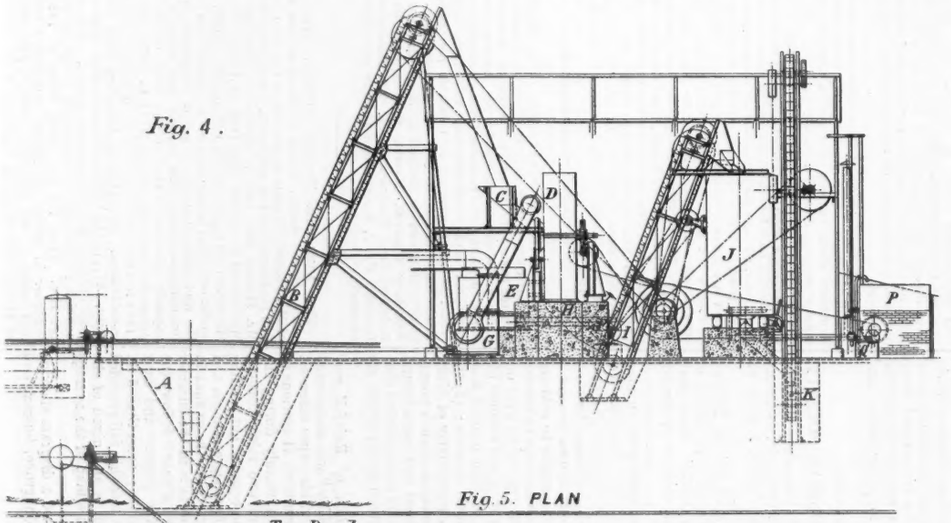


Fig. 6.

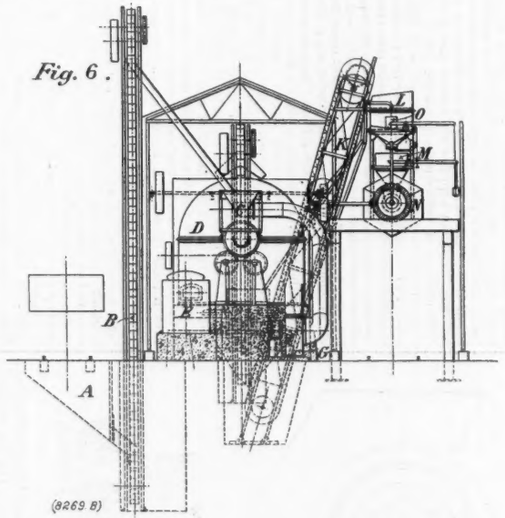


Fig. 5. PLAN

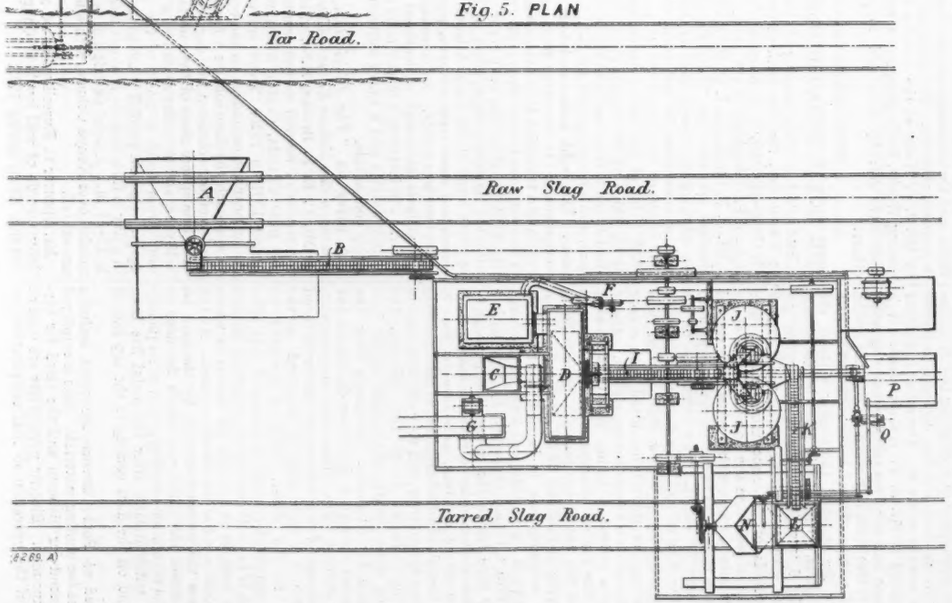


Fig. 7.

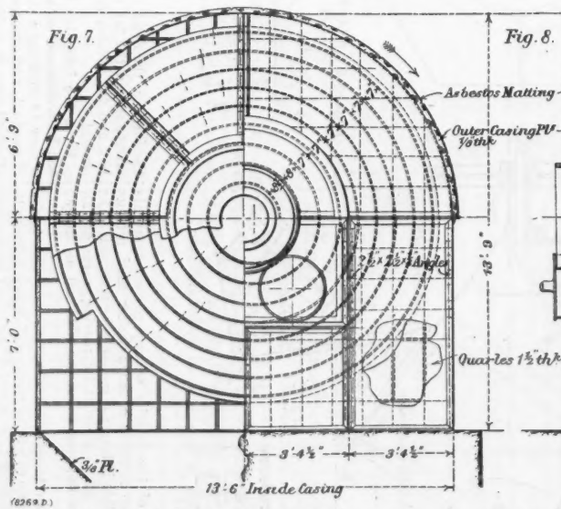
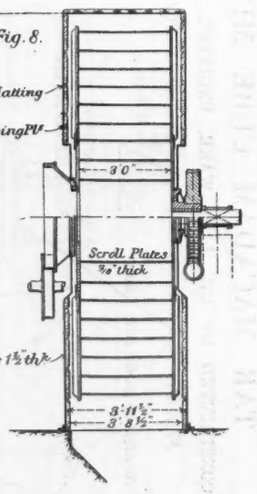


Fig. 8.

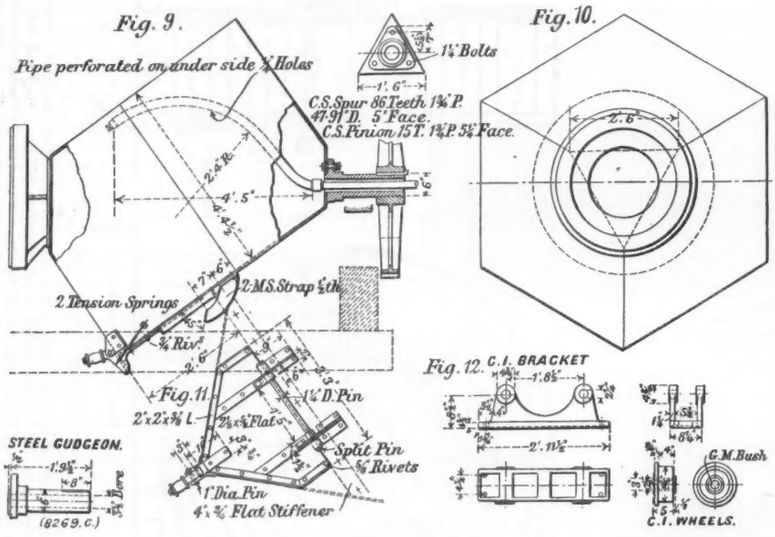


1,000 deg. F. are found to be most suitable for ordinary working, but temperatures have, of course, to be changed to suit climatic conditions and the state of the material to be dried. It may here be said that it is also possible to change the speed of the whole plant in three steps of fast, medium and slow, to meet different requirements of the aggregate. Any dust which dries off the aggregate is drawn through the scroll by the exhausting fan and passed on to separators which, however, the general drawings do not show.

From the drier the material falls into a hopper fitted with an adjustable discharge gate delivering to a bucket elevator I. The latter raises it to a distributor which supplies two vertical cylindrical hoppers J in which the hot slag or stone is stored. Such storage hoppers are now recognised as being of considerable benefit in tar macadam plants. They not only permit the heated material to cool to the temperature required for the mixing stage, but they allow sufficient time to elapse before the mixing stage for moisture to be

TAR MACADAM CUBE MIXER.

CONSTRUCTED BY MR. J. F. WAKE, ENGINEER, DARLINGTON.



driven out of the interior of any porous aggregate present, thus ensuring a much better final product than is possible if internal moisture be retained. The final drying out is assisted by passing warm dry air through these hoppers, which are filled and discharged alternately.

From these hoppers or silos the material is fed through a chute to a third elevator K which delivers to a high level hopper L from which the mixer is supplied. This hopper is arranged with a weighing box M immediately below it, and from this the aggregate is passed down a chute into the mixer N. The mixer is another distinctive feature of Mr. J. F. Wake's plant. It is a cube in shape and revolves on diagonally opposite corners, and is free from any wings or paddles inside, the shape and setting adopted being sufficient to turn over and mix the material thoroughly without the help of such parts. The mixing plant is best shown in detail in Fig. 6, in which the aggregate weighing box will be noticed with its weighing beam, while Figs. 9 to 12 show details of the cube mixer itself. The material is discharged from the box through a chute which extends into the mixer through a large conical mouth similar to that fitted to the drier, and supported in the same way by rollers. This forms one of the trunnions of the cube mixer. The diagonally opposite corner is supported by a hollow shaft carried in a pedestal bearing, the shaft being fitted with a gear driven by belt and clutch from the main shaft. Above the mixer is a second weighing box O of smaller capacity for the tar or bituminous binder. This is supplied from the tar boiler, constant circulation in the system being maintained by an electrically-driven pump. The weighing box is carried on trunnions and can be tipped by a chain and lever to discharge its contents into a funnel connected by pipe with a curved spray pipe inside the mixer, the passage to the interior being effected by way of the hollow shaft on which the mixer revolves, as shown in Fig. 9. The binder is thus slowly discharged on to the aggregate while it is being turned over, and very effective coating results. Mixing occupies about two minutes, the material being subsequently discharged direct into railway wagons for shipment. Discharge from the mixer is effected through a flap door on one of the sides of the cubical body. This door is triangular, and at the corner of the box-shaped mixer is fitted a spring latch. A cam plate is arranged on the frame close to the mixer. This is mounted on a shaft and can be depressed by means of a treadle. When a batch is to be discharged the treadle is pressed and the cam brought in towards the mixer, in which position it fouls a roller on the door catch. As the mixer revolves the pressure exerted by the cam on this roller releases the catch and allows the door to fall open as the revolution continues, to be subsequently closed again automatically after the metal has been discharged and on the door coming to the top side of the machine.

As installed at Port Clarence the plant includes three furnaces for binding materials. One is employed for tar, a second for bitumen and the third for tar-bitumen compounds. Electric pyrometers are used at every stage of the operation so that temperatures at the furnace, the drier, silos, storage hopper above the mixer, and in the tar pipes between the tar weighing box and tar boilers, are kept under observation and control.

From the foregoing it will be seen that the plant has been designed with a great deal of care and with a view to ensuring a uniform and satisfactory quality of product, and the success with which this has been attended may be gathered from the extent of Messrs. Wake and Co.'s business at the Port Clarence Works in prepared material. The machines are manufactured by Mr. J. F. Wake at the Geneva Wagon and Engineering Works, Darlington, and a number of installations have recently been sold to public bodies and others.

THE ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this society was held on Wednesday, the 21st inst., at the society's rooms, 49, Cromwell-road, S. Kensington, Mr. C. J. P. Cave, M.A., J.P., President, in the chair.

Mr. J. E. Clark, Mr. I. D. Margary and Mr. Richard Marshall presented the "33*rd Report* (*New Series*) *on the Phenological Observations of* 1923." They dealt with a more than 50 per cent. increase of records (357 in all) on the top of the 35 per cent. increase in 1922. This at last meets the essential needs in most parts, whilst all are valued even where densest. Yet West Ireland, West and North Scotland are still almost bare, and urgent appeals for help are made for these parts. The eight tables and four figures present a conspectus of (1) the swing from warmth to cold and consequent transition from extreme earliness to lateness in flowers, insects and birds; (2) the sweep over our islands of the advancing wave of spring and summer life with the damming back effect of high ground and, opposite result of the warm Atlantic currents; (3) the consequent more rapid advance, particularly of birds, up our western coasts. By correlation all such phenological facts have high agricultural and horticultural value. For instance, it is once more demonstrated that winter warmth and a heavy autumn fruit harvest are rarely compatible.

A paper on "*The Distribution of Rainfall over Uganda, with a Note on Kenya Colony*" was contributed by Mr. C. E. P. Brooks, M.Sc. This paper discusses the results of rainfall measurements at 51 stations in and near Uganda, Central Africa, mainly during the period 1901 to 1920. There are two rainy seasons, falling near the equinoxes on the equator but tending to approach the June solstice a few degrees north and the December solstice a few degrees south, so that in each hemisphere most of the rain falls in the summer half-year, and the rainy season each year "follows the sun" from south to north of the country and back again. Uganda rainfall is moderate; more than 5 in. in a day is rare, and the heaviest monthly fall recorded is 17·85 in. A brief description is also given of the rainfall over Kenya Colony, with a map of the average annual fall.

Mr. Spencer C. Russell exhibited a diagram showing daily records of well levels at Chilgrove, Sussex, and Detling, Kent, during 1923.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The improved conditions obtaining in some of the finished branches finds little reflection in the market for raw and semi-manufactured materials. Since the beginning of the year, despite an easing in the force of Continental competition, prices have been on the decline, and though in no case is any substantial reduction shown in official quotations, instances are reported of offers well below listed rates. Steel billets are nominally maintained at 10*l.* per ton for hard basic, and 9*l.* for soft basic, and rather than accept unremunerative business below these figures, producers prefer to adopt a waiting attitude. Belgian supplies are dearer owing to internal difficulties, and deliveries unreliable, being subject to delays of six to eight weeks. The price of blast furnace coke is to be maintained at 24*s.* per ton to inland works in a further endeavour to stimulate the iron trade, which has been induced to make further reductions ranging from one to five shillings a ton in the hope of attracting sufficient business to cover outputs. The official rates now ruling for supplies delivered to local works are: West Coast hematites, 5*l.* 15*s.* per ton; East Coast hematities, 5*l.*; Lincolnshire No. 3 foundry iron, 4*l.* 15*s.*; Lincolnshire forge, 4*l.* 10*s.*; Derbyshire No. 3 foundry, 4*l.* 15*s.*; Derbyshire forge, 4*l.* 12*s.* 6*d.* Bars and sheets are unaltered, respectively being quoted at 13*l.* and 15*l.* per ton. Colliery developments in hand and in prospect furnish useful opening for the sale of heavy machinery and various kinds of materials and tools. One of the most prosperous concerns in the district is committed to the provision of a complete electrical generating station with a total capacity of 18,000 kw., equipment for the working of a new seam, the shaft for which has been sunk, reorganisation of a compressed air plant, and a large number of additional houses for workpeople. Still another pit-sinking enterprise, following the success achieved at Armthorpe, is contemplated in the Doncaster coalfield. Sub-contracts placed last year on British railway account are nearing completion, and producers of locomotive and wagon parts report considerable difficulty, in face of exceptionally keen competition from State-aided industries, in obtaining sufficient new business to keep plant in operation. On the other hand rising sales are the rule rather than the exception in the lighter sections. Out-put of saws, axes, files, rasps, carpenters' and joiners' tools has increased something like 20 per cent. as compared with a year ago, while the overseas demand for shovels, forks, spades, horticultural and agricultural tools is nearly double that of the respective period in 1922. The effect of the proposed Indian steel and engineering tariffs is viewed very seriously by Sheffield manufacturers, who in the course of negotiations have thrown the full weight of their protective organisations in an effort to retain for this and allied trading districts the prospect of a reasonable share of Indian business.

South Yorkshire Coal Trade.—The seasonal slump in the demand for house coal, notably from consumers in Southern districts, has induced a further revision in values ranging from 1*s.* to 3*s.* per ton. Supplies are ample to meet all requirements, but collieries are not yet overburdened with stocks. Industrial requirements are maintained at a fair level despite the continued quietude in exports, though the release of an increased tonnage for open market disposal tends in the direction of terms which are more favourable to buyers. Washed slacks represent the strongest feature in smalls. Quotations best branch handpicked, 34*s.* to 35*s.*; Barnsley best Silkstone, 28*s.* to 29*s.*; Derbyshire best brights, 28*s.* to 30*s.*; Derbyshire best house, 25*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* to 25*s.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 24*s.* to 25*s.* 6*d.*; Derbyshire hards, 21*s.* 6*d.* to 23*s.* 6*d.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

CONGRESS OF REFRIGERATION.—The Fourth International Congress of Refrigeration is to meet at Westminster from June 16 to 21. A second week is set apart for a series of excursions to the leading refrigerating ports, including the London Docks, Bristol, Manchester, Liverpool and Southampton, to which free railway travel is being granted to Congress members. Receptions and luncheons are also announced. Congress membership can be secured on application to the Hon. Secretary General, Fourth International Congress of Refrigeration, Weavers' Hall, 22, Basinghall Street, London, E.C 2, from whom further particulars can be obtained.

THE LATE MR. HAROLD HOMAN.—We regret to announce the death, which occurred on the 24th inst., of Mr. Harold Homan, a partner in the firm of Homan and Rodgers, Limited, engineers, London and Manchester. Mr. Homan had been a member of the Institution of Mechanical Engineers since 1888, and was 74 years of age. He served his apprenticeship from 1862 to 1867 in various works and then spent one year as engineer on board ship. He was engaged in the Sclessin Ironworks, Liége, as a draughtsman from 1868 to 1869, and acted in the same capacity in works in this country down to 1871, when he proceeded to South Africa (1871 to 1873), then to Peru (1873 to 1877), where he was occupied on civil engineering installations. Mr. Homan travelled from January to July, 1877, in the United States, calling upon the leading machine-tool and locomotive works, with a view of acquiring information concerning American engineering practice. Then for ten years, down to 1887, he was engineer in charge of Messrs. Mucklow's works, Bury and Glasgow. He became, in 1888, a partner in the firm of Homan and Rodgers, Limited.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The market is weak and without new feature of moment. Inquiries circulating result in little business, buyers having adopted a most cautious attitude, and showing marked disinclination to negotiate except for supplies sufficient to meet early essential needs. An unsettled feeling has taken possession of the market, and the outlook at present cannot be described as otherwise than discouraging. Stocks of Cleveland pig iron are low, but unless demand speedily improves, accumulations of iron at makers' works are threatened. No. 1 Cleveland is on sale at 96*s.*; No. 3 g.m.b. is 90*s.* 6*d.* to 91*s.*; No. 4 foundry is 90*s.*; and No. 4 forge, 89*s.* 6*d.*, all f.o.b. Tees, rather below these figures being named for iron f.o.t. makers' works.

Hematite.—Sales of East Coast hematite have become slow, and values show downward movement. In this branch also producers' stocks are small, but unless demand expands they threaten to increase. Several sellers still name 98*s.* 6*d.* for Nos. 1, 2 and 3, but that is a very full quotation and buyers state they can place orders at 98*s.* No. 1 is put at sixpence above mixed numbers.

Foreign Ore.—Complete stagnation, so far as new business is concerned, continues to characterise foreign ore, and, in the absence of sales, market rates remain nominal on the basis of best rubio at 23*s.* 6*d.* c.i.f. Tees.

Blastfurnace Coke.—Durham blastfurnace coke keeps deadly dull and values show further downward tendency. Good average qualities are round about 27*s.* 6*d.* delivered to local consumers.

Manufactured Iron and Steel.—In finished iron and steel demand is very quiet and prices are easy, the steel department, however, being an outstanding exception. Revival in demand for sheets has caused quotations to take an upward turn. Owing to lack of orders, Messrs. Dorman, Long and Co. are closing the rolling mills at their North-Eastern steelworks. Among the principal market quotations are: Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 10*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; black sheets, 12*l.* 15*s.* to 13*l.*; and galvanised corrugated sheets, 17*l.* 5*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—As usual the South Wales Miners' Federation have decided to advise the Welsh miners to vote for a rejection of the proposed terms of settlement for a new wages agreement. It seems to be that no matter what concessions are made by the owners the representatives of the Welsh miners always vote to reject the terms. It may, however, be regarded as a foregone conclusion that the terms will ultimately be accepted. Serious trouble has now arisen in the Sisbewy Valley and already some 14,000 men have been rendered idle. The tangle has arisen from a dispute at the Markham colliery belonging to the Tredegar Iron and Coal Company. Strenuous efforts were made by the Miners' Federation officials to avoid joint action by other lodges but in this endeavour they were unsuccessful. The general manager of the Tredegar Company refuses to meet a deputation concerning the dispute until the Markham men resume work, with the result that the Markham men have called upon the miners in the adjacent collieries to come out in sympathy. Another unofficial strike is also threatened in the Rhondda Valley owing to the introduction of double shift working at the Ynysfero colliery, Treherbert. The 1,450 men have tendered a fortnight's notice and the company has in consequence given notice to some of their officials. Meanwhile, as a result of stoppages the supply of free coal has been somewhat reduced, but is generally still sufficient to meet the limited requirements of buyers. Prices, however, were steadier on the basis of 28*s.* for best Admiralty large, 24*s.* 6*d.* to 27*s.* for Monmouthshires, 25*s.* to 27*s.* 6*d.* for drys and 16*s.* to 18*s.* 6*d.* for smalls, according to quality. Exports of coal as cargo from South Wales last week amounted to 486,890 tons compared with 531,630 tons in the preceding week. Shipments to France amounted to 219,440 tons, Italy 51,260 tons, South America 61,250 tons, Spain 26,210 tons, Portugal 16,030 tons, British coaling depots 36,490 tons, and Canada 10,740 tons. Exports from Cardiff totalled 268,910 tons, from Newport 86,240 tons, from Swansea 76,500 tons, from Port Talbot 44,180 tons and from Llanelly 11,040 tons.

Iron and Steel.—Exports of iron and steel from the Welsh ports last week amounted to 23,759 tons which were well in excess of the previous week's shipments when 11,339 tons were shipped. Tinplates and terneplates comprised 16,053 tons compared with 7,649 tons; blackplates and sheets, 3,844 tons against 743 tons; galvanised sheets 3,034 tons against 2,200 tons; and iron and steel goods 827 tons against 247 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A more hopeful feeling prevails in the Scottish steel trade this week, but there would seem to be little to account for it beyond the placing a few more shipbuilding contracts. Once that industry gets going a fair amount of ship plates should be required, but at the moment the demand is not heavy. The outlet for sections and general railway material is still quite good, and there are also a number of respectable inquiries going round the market. Little change falls to be recorded in the black sheet trade, and the demand continues poor. The export, as well as the home side of the trade is quiet this week. Prices are unchanged, over the week and are as follows:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton; all delivered Glasgow stations.

Malleable Iron Trade.—There has been no appreciable improvement in the West of Scotland malleable iron trade during the past week. Few buyers are placing any fresh business, and existing contracts are the main source of employment at present. The steel re-rolling branches continue to do fairly well, and have quite a lot of work on the books. No change has been made in prices, and "Crown" bars are still quoted at 12*l.* 10*s.* per ton at Glasgow stations.

Scottish Pig-Iron Trade.—Movement in the Scottish pig-iron trade has been of a very restricted nature since last report, and buyers continue to hang back. While the current output is on the small side, it is more than ample to meet all demands, and stocks even are increasing. A few inquiries in the market this week may result in business, but the tonnage overall is not very heavy. Prices are keeping steady and are as follows:—Hematite, 5*l.* 2*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at makers' yards.

Wages in the Iron Trade Advanced.—The joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board have received intimation from Sir John M. MacLeod, C.A., Glasgow, that he has examined the books of the employers for the months of March and April, 1924, and certifies that the average selling price brought out is 12*l.* 7*s.* 11·93*d.* An increase of 2½ per cent. will therefore now be paid to the workmen as per the sliding scale agreement, for the two months commencing June 2.

Shipments of Scottish Pig-Iron.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, May 24, only amounted to 241 tons. Of that total, 156 tons went foreign and the balance of 85 tons went coastwise. For the corresponding week of last year the figures were 1,310 tons foreign and 70 tons coastwise, making a total shipment of 1,380 tons.

THE INSTITUTE OF STRUCTURAL ENGINEERS.—At a meeting of this Institution held on the 22nd inst., it was announced that for the session 1924–1925 Major James Petrie had been elected president, and Mr. H. J. Deane, Dr. J. S. Owens, Sir Charles Ruthen and Mr. H. K. G. Bamber, vice-presidents.

THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS, LIMITED.—This society has issued its twenty-second annual report, being the account of the transactions of the year 1923, presented at the annual general meeting of members held on the 15th inst. The record of the activity of the various sections is particularly interesting. The society announces that Mr. Frank Lanchester has been re-elected president of the Bureau Permanent International des Constructeurs d'Automobiles, which body is representative of the Motor Manufacturers' organisations in Great Britain, Belgium, Czecho-Slovakia, France, Holland, Italy and Spain.

ELECTRICALLY-OPERATED PORTAL CRANES FOR ANTWERP.—H.M. Consul-General at Antwerp reports that the Direction de L'Outillage du Port, Antwerp, are inviting tenders for the supply, delivery and erection of 15 electrically-operated portal cranes each of 3 metric-tons capacity on the No. 3 dock of the "Quai du Nord." Sealed tenders which must be accompanied by a deposit of 110,000 fr., will be received at Antwerp up till June 26. United Kingdom firms in a position to supply British materials can obtain further particulars from the Department of Overseas Trade, 35 Old Queen-street, London, S.W.1, quoting reference 22843/F.W./E.C.(A) 2.

MARCONI WIRELESS TELEGRAPH SERVICES.—An attractive booklet containing a description, in popular language, of the methods employed by Messrs. Marconi's Wireless Telegraph Co. Ltd., Marconi House, Strand, W.C.2 in dealing with messages received for transmission by wireless telegraphy has reached us from that company. Services are in regular operation between London and Paris, Berne, Madrid, Barcelona, Vienna, New York and Montreal, connections being available between all the foreign cities mentioned and other parts of the country or Continent on which they are situated. Full particulars of rates and routes are obtainable from the Traffic Manager, Radio House, 2–12, Wilson Street, E.C. 2.

DANISH STATE RAILWAYS THIRD CLASS SLEEPING CARS.—The Danish State railways, as an experiment, recently put third-class sleeping cars on the Copenhagen-Rauders line. These have worked so satisfactorily that it has been decided to run third-class sleeping cars on other main lines. The International Sleeping Car Company will build the carriages and let them on hire to the State railways. The carriages will be of a larger and improved type and will contain both second and third-class compartments, with respectively 12 and 18 berths in each carriage, two berths in each compartment of the former and three in those of the latter. New routes to be supplied with third-class cars are the Copenhagen-Esbjerg and the Copenhagen-Tingler route, the service being maintained on the Copenhagen-Randers route.

NOTICES OF MEETINGS.

THE ROYAL SOCIETY OF ARTS.—Monday, June 2, at 5 p.m. at John-street, Adelphi, W.C.2. Dominions and Colonies Section. "The Mandate System and the British Mandates," by the Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O.

THE SOCIETE DES INGENIEURS CIVILS DE FRANCE: British Section.—Tuesday, June 3, at 6 p.m., at the Institution of Mechanical Engineers, Storey's Gate, S.W. 1. "The Port of Havre," by Monsieur Michel Schmidt.

THE INSTITUTE OF METALS.—Wednesday, June 4, at 8 p.m., at the Institution of Mechanical Engineers Storey's Gate, S.W. 1. Fourteenth Annual May Lecture: "Atoms and Isotopes," by Dr. F. W. Aston, F.R.S.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday June 6, at 9 p.m. The Evening Discourse will be delivered by Lord Rayleigh on the "Glow of Phosphorus." Afternoon Lecture, Tuesday, June 3, at 5.15 p.m. Major W. S. Tucker on "Acoustical Problems" (Lecture II).

THE RADIO SOCIETY OF GREAT BRITAIN: TRANSMITTER AND RELAY SECTION.—Friday, June 6, at 6 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Informal Meeting. Lecture by Captain A. G. St. Clair Finlay on "Modulation Systems."

WELDING ENGINE CYLINDERS.—Messrs. Barimar, Limited, 14 to 18, Lamb's Conduit-street, Theobald's-road, W.C. 1, inform us that recently a motorist, when driving in a reliability trial encountered a water splash; the sudden contact of the metal, hot with fast driving, with the cold water caused the two cylinders of his machine to crack. The cylinders were welded by Messrs. Barimar so successfully that they are said to be in every respect in perfect working condition again. The cost was far less than that of new cylinders, and the time taken by the work was only a few days.

THE PHYSICS OF TEXTILE FIBRES.—One of the Sessions of the Empire Textile Conference which will be held at the British Empire Exhibition, Wembley, during Whitsun week will be devoted to a general discussion on "Physical and Physico-chemical Problems relating to Textile Fibres." This discussion is being arranged jointly by the Faraday Society and the Textile Institute, and it will be held on Wednesday, June 11, from 2.30 to 6.30 p.m. in Conference Hall No. 4. The Introductory Address will be given by Dr. W. Lawrence Balls and the programme of 12 papers includes contributions from all the leading laboratories in Great Britain and Ireland engaged in Textile Research. Full particulars may be obtained from the Secretary of the Faraday Society, 10, Essex Street, London, W.C.2., or from the Secretary of the Textile Institute, St. Mary's Parsonage, Manchester.

BOARD OF TRADE EXAMINATION FOR MARINE ENGINEERS.—The Mercantile Marine Department of the Board of Trade have issued a notice to the effect that it has been decided that, in future, service as second in seniority in the engine room of a vessel propelled by two or more sets of engines may be accepted as qualifying for a first-class certificate. Service in the engine room as assistant engineer below this rank will also be accepted, but only at half the actual time value. Candidates who qualify in this way will, however, be subjected to a somewhat more searching examination than those who have performed their qualifying service as senior engineer in full charge of a watch. Another point referred to in the notice is that future applicants for examination will be required to produce testimonials signed by the chief engineers of the vessels on which they have served, and testimonials issued by superintendent engineers will not as a rule be accepted as alternatives, as has been the case hitherto.

MACHINERY SURVEYS OF PASSENGER STEAMERS.—Some important modifications in the Board of Trade Regulations relating to the surveys of the machinery of passenger vessels are contained in the instructions to surveyors recently issued by the Marine Department. From these it appears that, in the case of passenger steamers with more than one propeller, only one complete engine and its auxiliaries need be surveyed every twelve months, instead of a complete survey of all engines and auxiliaries being required to be made each year, as must still be done in the case of single-screw steamers. All vessels, moreover, may in future be surveyed on the running-survey principle, so that the various parts surveyed need not all be opened up at the same time, so long as the required proportion of the machinery is seen in the course of a year, and the parts requiring annual survey are seen within 12 months of the previous inspection. The brickwork and bridges in the furnaces and combustion chambers of new cylindrical boilers need not now be specially taken down during the first four years, provided there is no evidence of leakage of corrosion in the adjacent parts of the boiler, but this does not apply to water-tube boilers. The lagging of iron or steel steam pipes need not be removed at the first periodical test, except sufficient round the back of the flanges to ascertain that the connections of the latter are tight, and the coils of distillers need not be subjected to hydraulic test if the ship carries an ample supply of fresh water and is engaged in short Transatlantic voyages. The instructions, which are obtainable from H.M. Stationery Office, price 1d., also relate to the heating of crew spaces, exhaust ventilators from crew or emigrant spaces, and the survey of life-saving appliances.

THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.

MR. J. H. BUTTERS, M.I.E.E., CHIEF ENGINEER AND GENERAL MANAGER, HYDRO-ELECTRIC DEPARTMENT OF TASMANIA, ENGINEER

(*For Description, see Page* 694.)

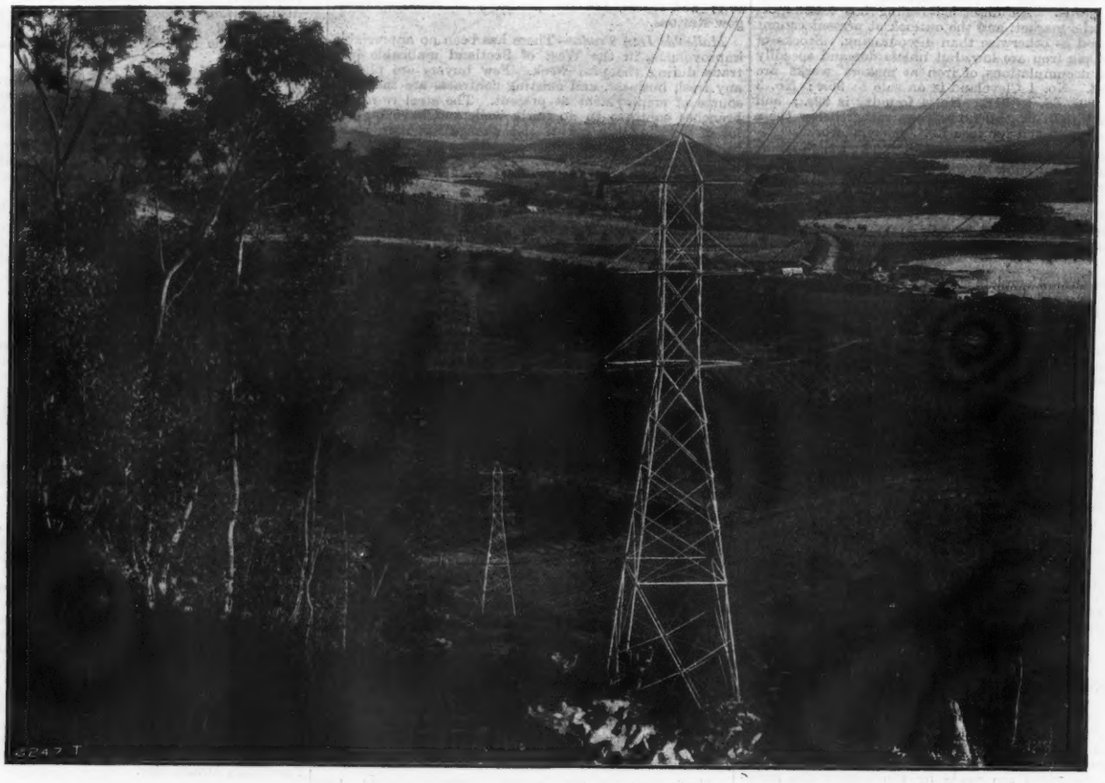


FIG. 77. TYPICAL VIEW OF NO. 2 TRANSMISSION LINE TO RISDON SUB-STATION.

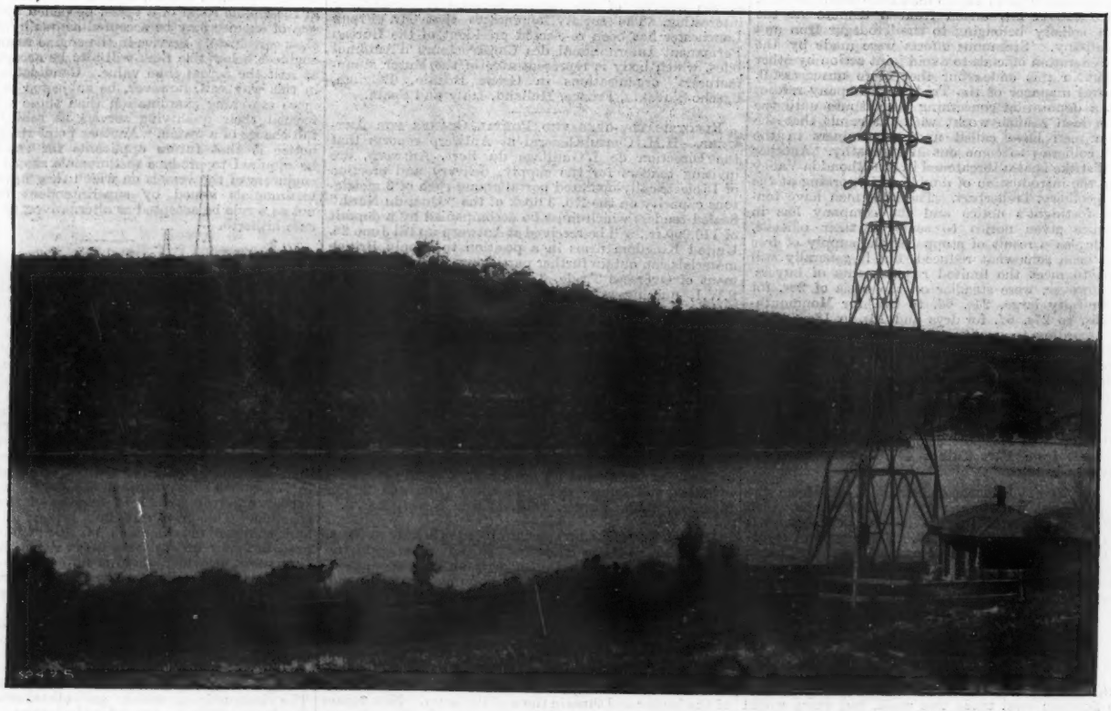


FIG. 78. NO. 2 TRANSMISSION LINE CROSSING RIVER DERWENT AT RISDON.

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With Four One-Page Plates.—1,000-*I.H.P. EXPERIMENTAL FOUR-CYCLE NORTH-EASTERN-WERKSPOOR DOUBLE-ACTING DIESEL ENGINE.*

ENGINEERING.

FRIDAY, MAY 30, 1924.

PHYSICS AND ENGINEERING.

THE itinerant conjurer, who wanders from village to village and from school to school, often professes to show his wondering audience exactly how certain tricks are done, but he would seem either to overrate his gifts of exposition or the sagacity of his audience, since his hearers never succeed in repeating the feat, in spite of the careful instructions tendered. In his presidential address to the Institute of Physics, Sir Charles Parsons explained exactly how he had raised the status of the steam turbine from that of a philosophic toy to the position of the chief of prime movers, but we greatly fear that the average clever man who hopes to achieve pioneering work of similar importance by following the procedure outlined, would fail as hopelessly as the schoolboy and the yokel in their practice of conjuring. No doubt it is quite true, that work of the character in question requires the collection of data before the general line of attack can be settled, and many preliminary experiments must be made. The accumulation of data, however, whether pre-existing or newly determined is *per se* as inadequate in invention as the corresponding Baconian method of scientific research has proved to be in the fields of physics and chemistry. The fact is that not all data are pertinent, and of pertinent data, not all are equally important. The pioneer both in science and engineering requires therefore to be endowed with the artist's gift of recognising and selecting from innumerable "presentations" the master items, and must discard or disregard either temporarily or permanently the vast residue. Indeed, as pointed out in the "Natural Philosophy" of Thomson and Tait, a similar procedure is necessary in even so academic a subject as theoretical mechanics, in which progress has been possible only by a systematic ignoring of unessentials. An accurate investigation of the phenomenon involved in the lifting of a heavy mass by a crowbar, would require the discussion of the motion of every particle, both of the lever and the weight, and the problem accordingly became attackable only when some unrecorded philosopher evolved the concept of perfectly rigid bodies. In this way a solution was found, but though sufficient, it is no longer exact. In the same way the engineer who hopes to attain success in new fields must at the outset content himself with rough approximations.

Thus Watt's experiments on steam, which formed the basis of his epoch-making invention of the separate condenser, were very inexact ; and in the same way the exceedingly ingenious experiments, on which Sir Charles built up his own success, might possibly excite the derision of the trained research worker. In the hands of their author, however, they proved adequate, but the gift of realising what will be sufficient and what may be dispensed with in such a research, is only associated with a touch of genius.

There is, as Sir Charles observed, little scope for higher mathematics in work of this kind. Indeed, the Michell thrust bearing seems to stand alone as a pioneering invention directly attributable to the originator's familiarity with partial differential equations. In general, however, it is only after a novel departure has already made good that the mathematician can be of much service, and the same consideration holds with regard to factory departments for research. Such an establishment, properly directed, has again and again led to vast improvements in products, and some of our pre-war industrial difficulties were undoubtedly directly due to an inadequate recognition of this fact.

A very striking instance of this was brought forward by Professor Arnold, who, when his steel-melting plant was first installed, insisted on using imported German refractories, to the intense indignation of certain local makers. One of the latter declared that he would be ashamed to work up a material showing so poor an analysis as the imported ware. In spite of its chemical defects, however, the foreign refractory was found by Professor Arnold to withstand many more heats than the apparently superior quality tendered him from home sources. In fact, by means of laboratory research the foreign makers had learnt how to work up their somewhat indifferent raw materials into highly-resistant firebrick. Once it is known that a thing can be done, it is generally not very difficult to learn how to do it, and in the course of a little time Professor Arnold was able to obtain from home makers, firebrick at least as good as the imported article.

This incident emphasises another matter upon which Sir Charles laid stress, viz., that physicists and others, because some foreign-made piece of apparatus is at some particular period superior to the competing home alternative, often assume that this superiority is indefinitely maintained, and persist in ordering and recommending it, long after it has been equalled and surpassed by a British product. A notable instance of this tendency occurred during the war in connection with the photographic objectives used in aerial surveying. German lenses had acquired a deservedly high reputation, but continued to be demanded by aviators even after the best of them had been surpassed by the British-made Cooke lens, as was proved to be the case by careful and comprehensive official tests.

In concluding his address, Sir Charles drew attention to the extremely difficult position in which our makers of scientific apparatus were left at the end of the war. To meet the demands of our forces, they had enormously increased their establishments, patriotically sinking in plant and buildings sums which might have been more safely and remuneratively otherwise invested. Though recognised as a key industry, Parliament has, since the war, done little or nothing to help, mainly, it would seem, because the industry as a whole is a small one, the total capital involved being about 2,000,000*l.*, and worth now one-half to one-third of that sum. In fact, it would almost seem that the House of Commons, though it would certainly summarily reject any proposal that Germany should pay the reparations due in the form of coal, views with indifference the extinction of small or

infant industries, looking, so to speak, on "infanticide" as a pardonable indiscretion, whilst objecting to any attack on the full-grown mining industry. This it does, in spite of the circumstance that cheap coal would be an enormous advantage to the rest of the nation.

As matters stand, however, Parliament is to-day perhaps less inclined than it was in 1883 to take an active part in the "murder" of a nascent industry, but it has hardly yet in these matters reached beyond the stage exemplified in A. H. Clough's version of the sixth commandment, which, it will be remembered, runs as follows:—

"Thou shalt not kill, but need not strive officiously to keep alive."

In view of the indifference of the powers that be, the best that can be hoped for, is that, as Sir Charles suggested, physicists should help in as close contact with makers as possible, letting them know their aims and their difficulties. In the second place, there should, as the lecturer urged, be less rivalry and more mutual helpfulness amongst the manufacturers themselves.

We have heard much of late as to the importance of science to the engineer, and it was well, therefore, that Sir Charles should also point out the indebtedness of science to engineering. This has not been confined to material aids only, but many of the fields which have been most profitably exploited by the physicist have been brought to his notice by the engineer. Thermodynamics traces a direct line of descent from the steam engine, and the electrical units and the sensitive galvanometer were originally introduced wholly to meet a practical demand.

THE RESOURCES OF THE EMPIRE.*

THE Prince of Wales has given his imprimatur to a work of epoch-making character. H.R.H. recognizing how many fail to realise the infinite variety and vast extent of the products of the Empire, sees in these volumes the materials for a great Imperial stocktaking, rendered the more necessary by the dislocation effected in the ordinary channels of commerce and industry by the Great War. These volumes were apparently designed to maintain and continue the enthusiasm awakened by the collection at Wembley. Every artifice is there employed to suggest enlarged opportunities to those who would seek other outlets for their energy, and to exhibit the conditions under which such energy would be utilised. Here the accurate information is supplied on which enterprise can confidently build, advantageous influences can be correctly estimated and competing schemes analysed. Every effort has been made to provide statistics as trustworthy as possible, and the reputation of the authorities quoted is such as to carry weight and confidence.

If Wembley supplies the occasion, the need for enquiry and examination goes far deeper, as Sir Eric Geddes points out in an introduction common to the several volumes. The problem of increased production is one that faces the nation, and the leaders of public opinion, while agreed upon the desirability of greater output are not unanimous in the choice of means to be employed. There are those who think the home trade is worth preserving, and that to offer to share it with the foreigner is suicidal. Others see the road to prosperity in the resuscitation of European trade and would sacrifice the present interest and latent prospects of Colonial and nascent communities to the settled and fully developed condition of older States. A third class sees the hope of the future in stimulating and encouraging the growing Colonies. Into the complexities of the competing schemes, no doubt sincerely recommended by diverse schools of thought, this is not the place to enter, nor have we the wish to discuss them. But it is possible to apply the test of statistics to many of the arguments that blind partizanship upholds, that oft-repeated parrot cries acclaim and interested judgments defend. The materials for weighing the misleading nostrums and for forming a deliberate independent opinion are to be found here, and form very solid grounds for recommending these volumes to an intensive perusal.

There are at this moment special reasons for studying such problems. Foreign tariffs are rising higher and higher against us all over the world, and the productive capacity of the individual is diminishing, while the population that has to be fed is steadily and uniformly increasing. No sophistry can get over the fact that a million more men have to be employed than in 1914. That is as unimpeachable as the multiplication table itself. Hunger is not unknown in the land, and the numbers unemployed and unemployable make it clear that the old methods long pursued with success in a less crowded world, are no longer capable of supporting the heavy burdens imposed by altered conditions, and a reorientation of commercial policy is forced upon the industrial world, and those who prefer to follow the familiar paths of custom and *laissez faire*, rather than to attack the difficulties that novel methods compel. Hence the necessity for a vigorous propaganda such as these volumes offer. They put before all a true picture of the production and distribution of the materials upon which our trade has been built up, and indicate how prosperity may be extended. The facts require careful study, exact comparison and judicious deduction, but to all who are desirous of mastering the trend of ordered development we can assure an ample recompense. By way of illustration we may instance the subject of *Fuel*, the basic Industry of the Empire.

1. *Fuel.*—The General Editor of the Section is Mr. G. W. Andrew, M.Sc., F.I.C., who has been assisted by several authorities of repute in their respective spheres. The introduction is the work of Sir Robert Hadfield, who from the outset adopts a comprehensive view that embraces the experience of the Old Country and surveys the resources and possible contributions of the Overseas Empire. Notwithstanding that other communities have been able to avail themselves of the energy possessed by flowing water, by wind, and possibly by sunshine, he by no means regards coal as seriously attacked as a source of energy or even tending to decline. This he attributes to the adoption of methods of use, suggested by the policy urged by the Fuel Research Board and similar organisations, that are actuated by a true scientific spirit, and he asks whether the time has not arrived when steps should be taken to effect co-operation between those helpful organisations, dealing with economy and research in the Mother Country, and those in the Dominions, in order that they may profit and avoid our mistakes. This suggestion is offered in the right spirit of altruism, and should tend to promote the economic use and scientific conservation of fuel.

The details concerning the existence of mineral fuel throughout the Empire are furnished by Professor Henry Louis, mainly in a series of well-arranged tables. The term mineral fuel is used here to include coal, properly so called, brown coal or lignite, and peat. Having an excellent supply of coal in Great Britain, little attention has been paid in this country to the utilisation of lignite and inferior kinds, but in these volumes, where we are made to appreciate that Great Britain is only part, however great, of an Empire, the importance of lignite is emphasised in the Dominions and in Canada, where forms of fossil fuel little studied in the mother country, are largely used. The distribution of coal and peat throughout the British Isles is dealt with very carefully, and, among other items, very full particulars are given of the practically unworked Kent coalfield, from which it may be gathered that this area will be rapidly opened out and will prove a very important addition to the coal resources of the country. From England and Ireland the survey proceeds to India, where the quantity of coal is more impressive than its quality, for the Indian coal usually possesses much ash, has large water content and cokes very imperfectly.

In South Africa the conditions obtaining in India are generally repeated, while in Natal and Rhodesia, difficulties of communications and insufficient pioneering work permit no very definite conclusions to be drawn. Australia is comparatively rich in coal, of a quality resembling the Permo-Carboniferous coal of Africa and Asia. On turning westward to America, improvement, however, is noticeable. The Empire contains about one-fourth of the world's reserves of coal, and of this quantity more than two-thirds are to be found in Canada. All kinds from anthracite to lignite are to be found, and the tabular information, especially that referring to Alberta, is most satisfactory. In addition to the distribution of coal, other questions arise concerning its disposal and employment in industry. The production of metallurgical coke, and coke-oven practice generally; the manufacture of gas works coke and of coal gas; the processes and objects of low temperature distillation; the carbonisation of low-grade coal, and the hydrogenation of coal and oils—all receive adequate attention, though of the last process, being still in the experimental stage, it would be premature to discuss its possibilities and applications.

The subject of fuel oils is discussed by Mr. A. W. Eastlake, who confines his description to the products of crude mineral oils, which can be utilised for the production of heat and power. The Empire has been less favourably treated in oils than in coal, and its production bears now a lower ratio to the total than in 1913. While the total world output in 1921 doubled that of 1913, the percentage produced by the British Empire decreased from 2·298 to 1·883 per cent. But if the percentage has declined, the total has increased. In 1913, the Empire contribution was 312 million gallons, and in 1921 this figure rose to about half a million gallons, but such figures are insignificant in comparison with the enormous production of the United States and Mexico, which together are credited with 87 per cent. of the world's total. The future of oil shale, of which the Empire possesses great quantities, is doubtful, because the life of the petroleum wells is uncertain, but it is probable that these shales may have to play no small part in furnishing crude oil, but at present the utilisation is not a commercial proposition.

II. *Ferrous metals.*—In the treatment of coal as a British Empire asset we have indicated the contents with some degree of fulness, in order to exhibit the general method pursued throughout the series. Of the remaining volumes, though the contents are not less interesting or important, much briefer notice must suffice. Mr. Arthur Dorman, of Messrs. Dorman, Long and Co., sketches the development the iron and steel industries have successfully pursued, and points out that of necessity a large proportion of his space must be devoted to the description of the activities of the Mother Country, since small communities cannot support the large organisations necessary for rapid progress. He recognises, however, that the Dominions will wish to assert themselves, and urges that they should be encouraged to develop industrially, as well as agriculturally. India is regarded as in a very favourable position, and it is anticipated will prove one of the world's greatest iron manufacturing centres. Mr. Birkett, the editor, adopts the view of the Imperial Mineral Resources Bureau, that the time is not far distant when India will be self-supporting as regards iron and steel, for pig iron can be produced comparatively cheaply, owing to the low assembly costs consequent on the close proximity of raw materials, and the cheap rates of freight. Mr. Birkett, with the assistance of able colleagues, conducts the reader through the great centres of manufacture, describing the Sheffield works, the tinplate works of South Wales, and the activities of the shipbuilding firms on the North-east Coast and in Scotland, everywhere providing abundant information and demonstrating progress.

III. *Non-ferrous materials.*—If it were impossible to do justice to the review of the ferrous minerals, it is still more difficult to consider the variety of details presented by the many problems connected with the non-ferrous metals, of which no less than 33 are described by Mr. N. M. Penzer and his colleagues, mainly from the point of view of geographical distribution and economic importance. The study of the statistics is, however, most illuminating. Owing to the abundance of coal and iron and the prominence these occupy in industry, we are apt to forget the essential characteristics

* *A Collection of Twelve Volumes, Constituting a Business Man's Survey of the Empire's Resources, Prepared by the Federation of British Industries.* With a foreword by H.R.H. THE PRINCE OF WALES, K.G., and general introduction by the Right Hon. SIR ERIC GEDDES. London: Ernest Benn, Limited. 1924. [Price 21*s.* per volume, 7*l.* 7*s.* the set of twelve.]

1,000-I.H.P. EXPERIMENTAL FOUR-CYCLE NORTH-EASTERN-WERKSPOOR DOUBLE-ACTING DIESEL ENGINE.

CONSTRUCTED BY THE NORTH-EASTERN MARINE ENGINEERING CO., LTD., WALLSEND-ON-TYNE, AND MESSRS. WERKSPOOR, AMSTERDAM.

(*For Description, see Page* 707.)

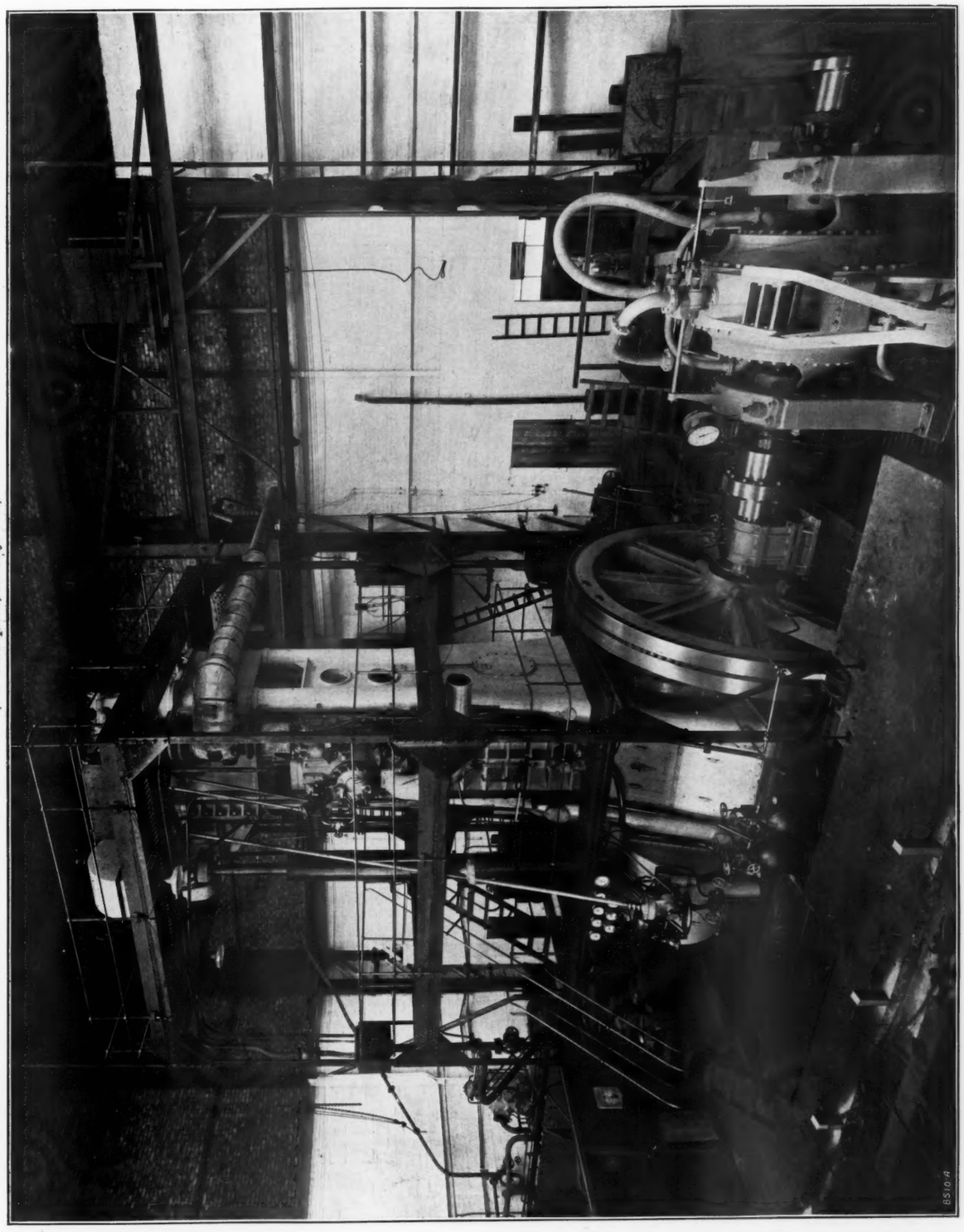

FIG. 1.

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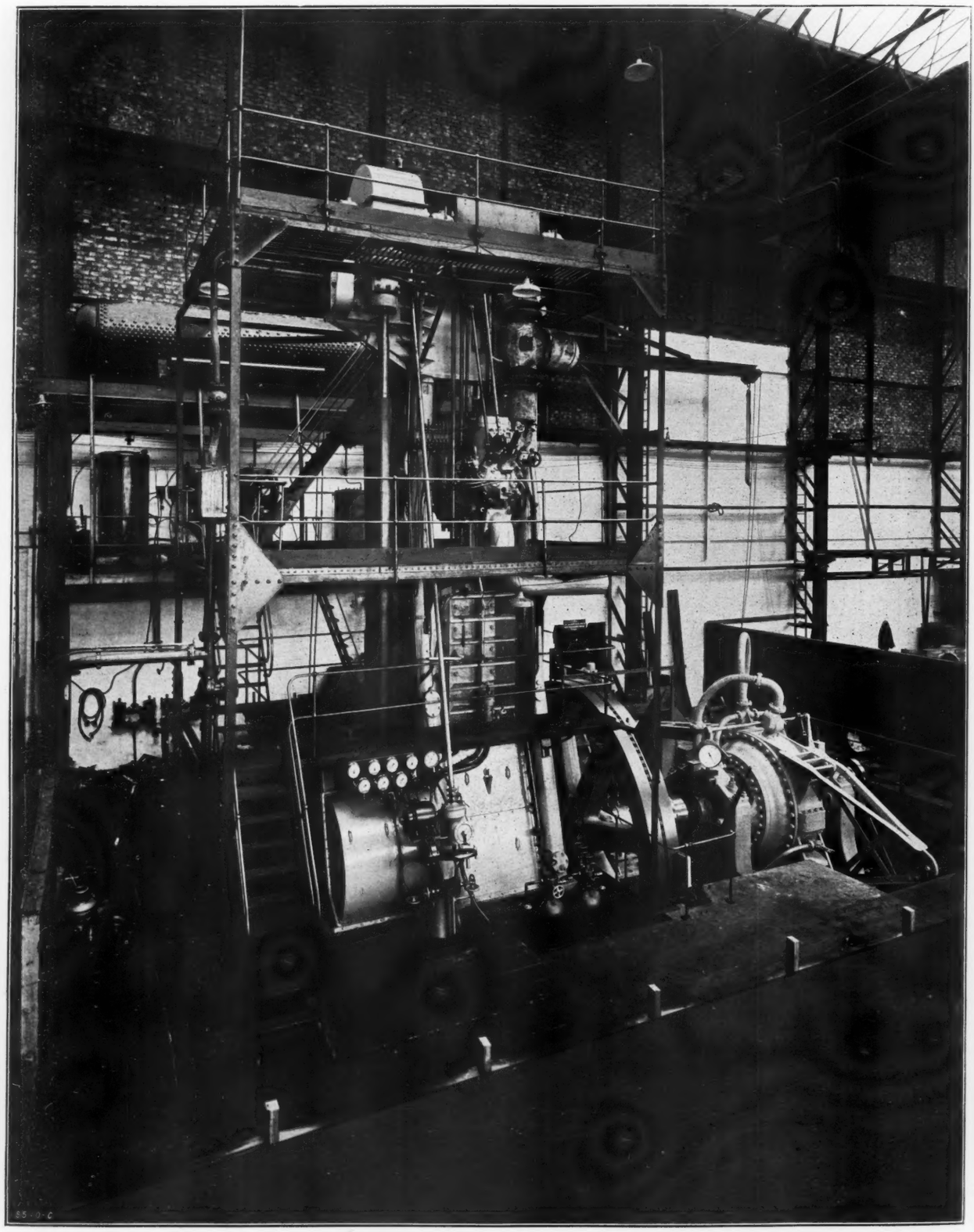

FIG. 2.

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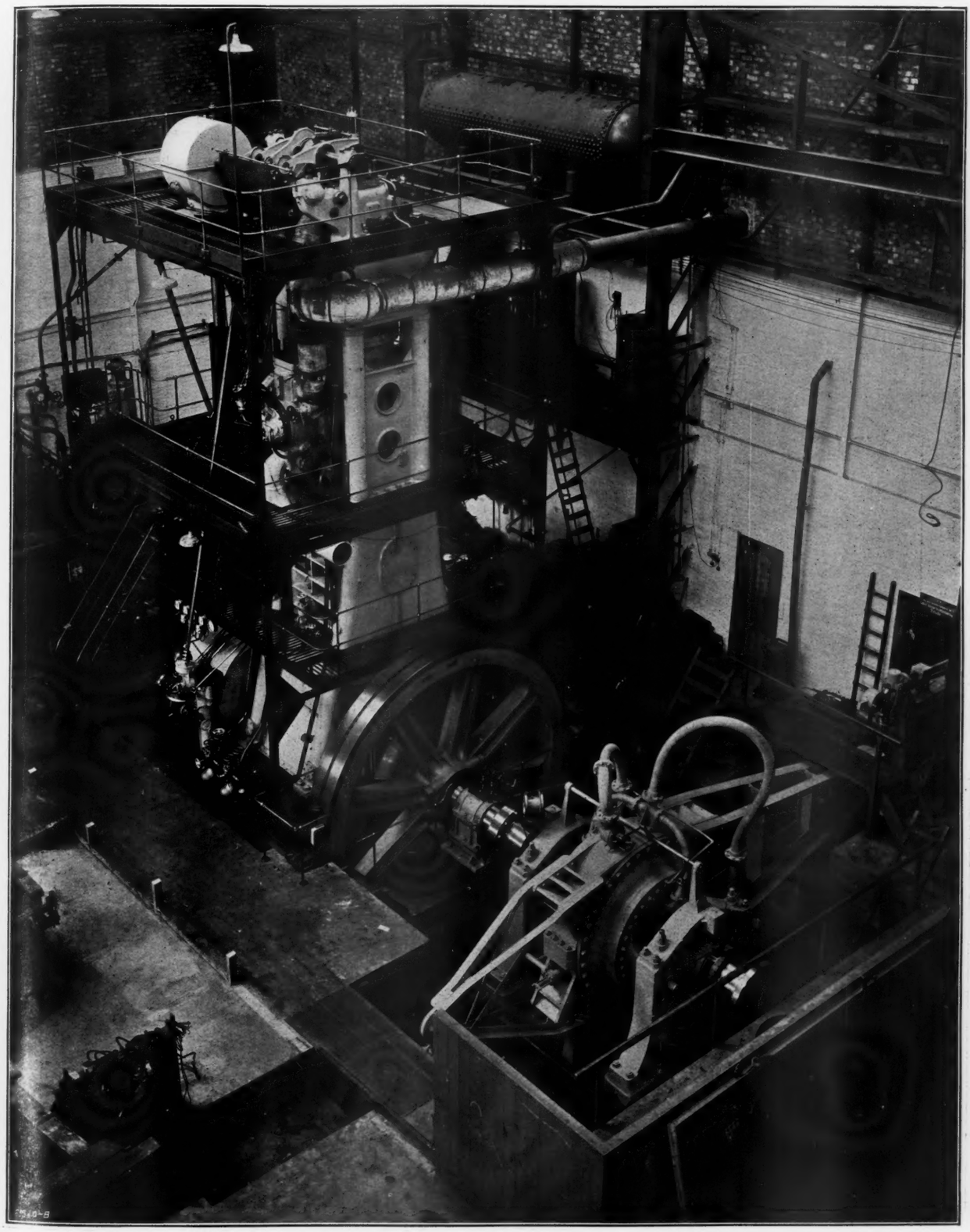

FIG. 3

1,000-I.H.P. EXPERIMENTAL FOUR-CYCLE NORTH-EASTERN-WERKSPOOR DOUBLE-ACTING DIESEL ENGINE.

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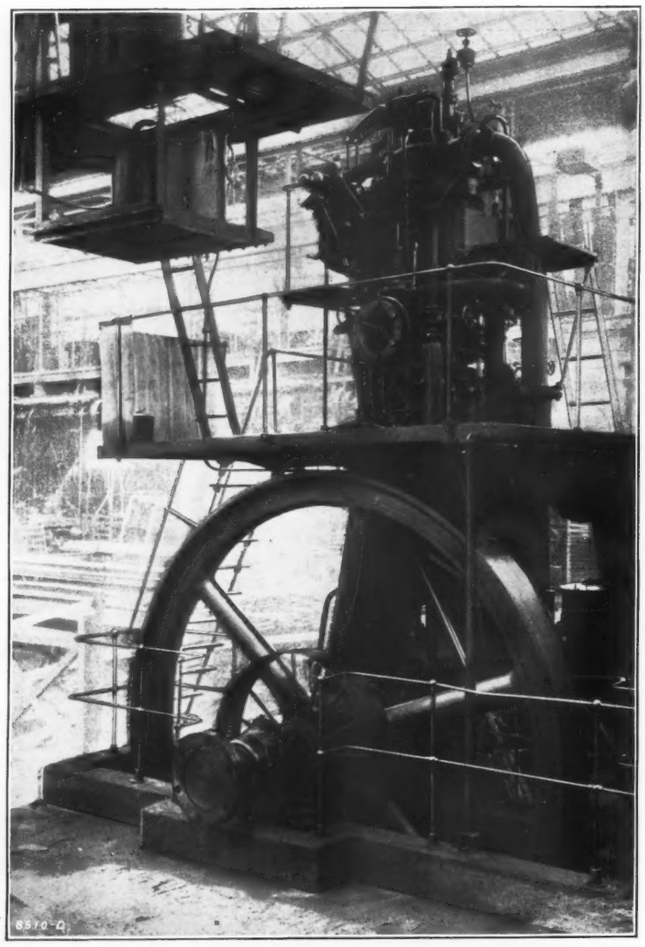
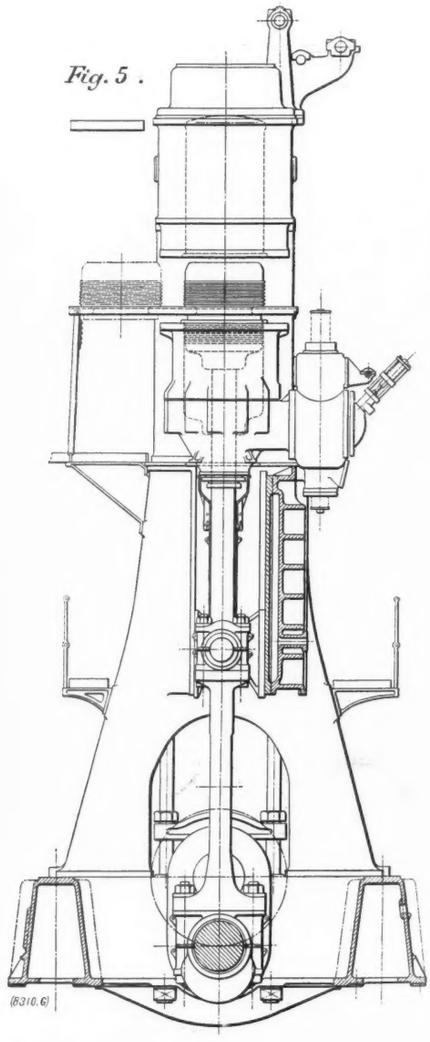


FIG. 4.

Fig. 5.



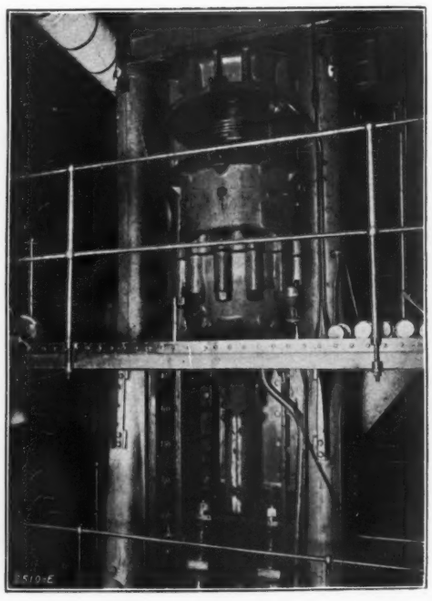


FIG. 6.

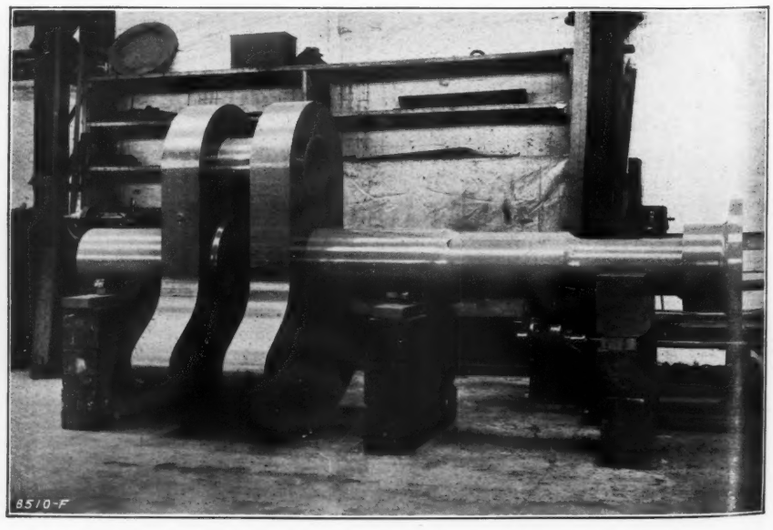


FIG. 7.

(*To face Page* 707.)

of some of the scarcer metals. Sir Richard Redmayne does well to remind us that if these less-considered metals were used up "civilisation as we now know it, would come to an end. The sources of power would exist, but not the means for its generation and transmission." In this volume, as far as its limits permit, this text is enlarged upon. No one can leave this book without being impressed with the prominent place occupied by these minerals in the world's economics and in inter-Empire trade. How long will the stores of tin, of lead, or of copper last? asks Sir Richard, and makes the growing scarcity of these indispensable metals the justification of the thorough and complete analysis of resources, undertaken in this work, so well calculated to advance the intensive and progressive development of Empire trade relations.

IV. *Communications.*—Lastly, under the guidance of Sir F. W. Lewis and Mr. W. T. Stephenson, we are invited to consider the importance of transport and communication in promoting the availability of Imperial resources. Low transport cost is absolutely vital to the maintenance of the Empire and its widely-flung Dominions, since grain and bulky commodities have to be handled in the markets of the Mother Country. To such main factors attention is principally directed, though there are interesting chapters on air transport suggesting the possible vehicle of the future. It may come with surprise to some to learn that the railways of the United Kingdom employ as many men as does ocean traffic, and that the L. M. and S. Railway alone requires a larger amount of capital than suffices to conduct the mercantile marine of the whole world. Merchant shipping has always occupied in the economic system of the world a place out of all proportion to the capital which it represents, or the number of persons employed in it. The facts related here enable us to correct some disproportionate views, and to acquire a clearer conception of what is necessary for the present maintenance and future development of an Empire whose scattered territories and varied climates furnish probably every necessity for the comfort and progress of mankind.

DOUBLE-ACTING MARINE DIESEL ENGINES.

THERE is being evinced at the present time a growing tendency by shipowners to demand steadily increasing powers for motor vessels. This movement arises from several causes. There is now no question of installing twin screws instead of the more usual single screws for the average cargo carrier on the score of the risks of unreliability of the oil engine. Generally, the present keen competition for the world's carrying trade is serving to enhance the value of higher average speeds of vessels, calling for the consequent increased power of the propelling unit. The growing popularity of the Diesel engine in widening fields of utility, including the largest classes of merchant vessels such as intermediate passenger liners calls thus also for greater engine power.

In the light of such generalities as the foregoing, it is interesting to reflect that whilst almost all steam reciprocating engines are double-acting, the great majority of internal-combustion motors of all types work on the single-acting principle, where the power impulses act solely upon one side of the working piston. The mechanism transmitting the power obtained from the expanding gases is thus only utilised for a relatively small fraction of the total running time. This cannot be regarded in any way as a final solution to the problem of economic power production. There are always excellent reasons for the predominance of any standard type of machine, and with internal-combustion, where the high temperature stresses call for free expansion, and the piston rings play such an important part, the advantages of single action have very great force.

However, the double-acting principle obviously reduces size and weight per unit of power output, which considerations have very great importance the higher the horse-power and cannot lightly be turned aside. There is the further gain in mechanical efficiency, and so in overall economy accruing from the smaller weights and lesser friction losses, for a given power. The turning moment is considerably improved. There have been in the past a number of double-acting internal-combustion engines, as, for example, the horizontal gas engines, favoured principally on the Continent, which have given such good service, for land duties, as to suggest early that the problems associated with making the vertical Diesel engine double-acting, are in no way insuperable. So far as the running gear is concerned, the increase in dimensions to cope with the reversal of load from compression to tension presents no problem. Gas engine experience with the piston rod and the stuffing box has evolved very satisfactory types for the relatively lower duties required in that particular application, and gives every confidence that this need not in any way be a serious deterrent.

Horizontal 4-stroke cycle and vertical 2-stroke cycle Diesel oil engines were tried in Germany prior to the outbreak of the war, but the failure of some of the earlier experiments, the rapid progress of the turbine for high-powered installation afloat, and the incidence of the war suspended activity and almost all interest in the subject for the greater part of ten years.

With the almost cyclic regularity of the laws governing the progress of scientific endeavour, this subject has again emerged from its temporary dormancy, economic necessity compelling renewed attention to it. It is the simple 4-stroke cycle principle that is being generally utilised now to provide double action for marine propulsion.

One of the earliest firms in this country to take up earnestly the study of the marine oil engine in all its aspects was the North-Eastern Marine Engineering Company, of Wallsend-on-Tyne, in conjunction with Messrs. Werkspoor, of Amsterdam. Messrs. Werkspoor engined the M.S. Vulcanus in 1910, and have since, with their British collaborators, been responsible for the machinery of a large number of motor ships. They are therefore one of the pioneers in the marine oil engine movement. During the last two and a-half years these two firms in conjunction have been developing a double-acting four-stroke Diesel engine and have had a new large single-cylinder unit running in the Wallsend shops for some months past. This engine on the test bed is illustrated on Plates LXVIII to LXXI accompanying this issue.

To some considerable extent the design of the engine under description is based on a smaller engine with a cylinder 450 mm. diameter by 680 mm. stroke, otherwise of similar construction, built by Messrs. Werkspoor and run in their Utrecht works for a period of about eighteen months. It was thought advisable to carry out the initial work on a smaller unit. This engine is illustrated in Fig. 4, from which it will be seen it conforms generally to the designs, as illustrated, of the larger engine.

The large unit was inspected at Wallsend-on-Tyne during a trial of twenty days at full load, to which it has just been subjected. The cylinder diameter is 800 mm. (31½ in.), with a stroke of 1,400 mm. (55 in.), and the normal continuous service indicated horse-power at 95 revolutions per minute is 750, corresponding to a brake horse-power of 600. The mechanical efficiency is 80 per cent.; appreciably higher than with a single-acting engine. The maximum indicated horse-power is 1,000 i.h.p.

This engine is a single cylinder unit for experimental purposes, but will be built in six- or eight-cylinder sets for marine work, to develop on the same number of cranks 3,600 and 4,800 brake horse-power. It is becoming recognised that the limit to-day with single-acting four-cycle engines is approximately about 3,000 to 3,500 brake horse-power developed in eight cranks.

The cylinder sizes of this particular unit were reached by adopting for the diameter and the stroke accepted successful practice with the single-acting four-stroke cycle marine engine to-day, although it is not considered that these dimensions represent in any way the limit of power to which engines of this type of construction can, and no doubt will, in due course, be constructed. An inspection of the illustrations (Figs. 1 to 7) of this engine indicate that in respect of the main parts, the designers have adopted an accepted design, as offering the maximum accessibility and reliability. The engine is of the direct-acting type in that the power impulses are transmitted directly from the piston through a single piston rod and connecting rod to the single crank, as is the case with the normal double-acting steam engine. The engine is forced lubricated throughout. The crankshaft is of the latest patent Unity type, in which the webs are shrunk on to the journals and crank pin, and welded. The construction is well shown in the photograph reproduced in Fig. 7. It will be noticed that large weights are provided by extensions to the two webs to balance the rotating masses; this being necessary only, of course, in the single-cylinder unit. The keyway for attaching the flywheel will also be observed. The drawing reproduced in Fig. 5 shows the general form of the framing and principal parts of the engine. In accordance with the normal practice of these constructors the main tension loads of the piston are taken directly through turned steel columns, which extend from the top of the cylinder to the base of the flat-bottomed bedplate. For rigidity, and in order to carry both the ahead and astern guide plates, double cast-iron columns of trestle form encircle these through-bolts or turned steel columns. By means of nuts threaded on at a suitable position the main bearing caps are retained by these bolts. The top half of the main bearing bush is separate from the cap, and so can readily be removed. A somewhat unusual arrangement of crossheads and guides is adopted, in that for the ahead lateral thrust one single guide plate is bolted between the columns, and for the astern two separate guide plates are bolted on the trestle columns themselves; three slippers are attached to each crosshead, one in the centre on the front of the engine for the ahead thrust, and two at the sides at the back for the astern. This arrangement makes the engine very accessible for overhauling and adjusting the main running gear. Telescopic pipes for piston cooling on the plunger system are anchored to the astern shoes, and a heavy gauge pipe connects to the piston rod, which is hollow for the passage in and out of the piston cooling water. In this engine, the water used for piston cooling is fresh water. The glands on the telescopic pipes are arranged in accessible positions above the crank-case top plate, where leakage is readily observed and cannot reach the crank-case.

The top portion of the cylinder is substantially of the normal North Eastern Werkspoor design, with the well-known reverse and starting gear, as is clearly shown in Fig. 3. The camshaft is driven from the crankshaft by means of bevel gearing and a vertical shaft. Manœuvring is carried out by rotation of the fulcrum shaft, upon which the valve levers pivot on eccentrics keyed at different angles on the shaft. Rotation of this shaft, and so of these eccentrics, lifts the roller end of the valve levers from off the appropriate ahead cam, and depresses them on to the adjacent cam for astern running. To the single camshaft there are added fuel exhaust and inlet cams for the bottom cylinder. These cams actuate the valves in the bottom cylinder through an arrangement of rollers and push rods (Figs. 1 and 2). Two additional cams are fitted on the starting shaft to hold open the bottom exhaust valve and shut the bottom inlet valve in certain positions of the starting shaft, as will be described later.

In the design of a double-acting internal combustion engine, very great interest unquestionably must centre in the means adopted for coping with the problems associated with the combustion on the underside of the piston and the provision there of a stuffing box for the piston rod. With this engine, a low pressure of compression is utilised on the underside of the piston, the figure being between 200 and 300 lb. per square in. This low compression pressure permits of a large clearance volume for the combustion chamber, so that it can be formed of a separate casting bolted on to the side of the cylinder head proper as may be observed in Fig. 5. Vertically placed one above the other are the inlet and exhaust valves, both in separate cages—the exhaust valve at the top and the inlet at the bottom. With the low compression pressure this chamber is of sufficient dimensions that these valves and cages are quite interchangeable with their corresponding

parts in the top cylinder head. The valves and cages are of standard design, the exhaust valve cages being water-cooled as is usual.

Special means are provided for ensuring ready ignition at this low compression pressure and for deflecting the flame away from the piston rod. No starting air is admitted to the bottom of the cylinder, as it has been found perfectly satisfactory for starting and reversing to give impulses on the top of the piston only.

For astern running in the ordinary way, no fuel is admitted under the piston. Ample power is developed over the top, with the Diesel cycle, for this purpose, as the effective piston area is considerably greater on the top than the bottom, due to the deduction resulting from the piston rod.

The fuel injection valve for the bottom cylinder is fixed at 45 degrees through an inspection door on the side of the separate combustion chamber as will be seen in Figs. 1, 2 and 4.

The low compression pressure is not sufficient to ensure ignition and combustion on the underside of the piston with a cold engine, and extremely ingenious and simple means are adopted to warm up the lower combustion space. The engine is set in motion by compressed air admitted in the usual way to the top of the piston, then fuel is turned on, and regular firing takes place on the top of the piston, when the exhaust valve of the bottom combustion space is held open by the engine-starting gear, and the bottom piston, on rising and falling, pumps exhaust gases from the top combustion chamber in and out of this space, so warming it up. A pyrometer is fitted to record the temperatures in the bottom exhaust port, and so soon as a temperature of 400/450 deg. F. is reached, the exhaust valve is allowed to function normally, fuel is turned on and firing commences. A very brief period suffices to attain this required temperature, and after stops of about half-an-hour's duration restarts can be made without resorting to this warming-up process for the bottom chamber.

Another method which might be adopted is steam heating, but it would require complications such as boilers, &c., and the present attractive and simple system is preferable.

Due to the low compression pressure in the bottom combustion chamber, and the means adopted for protecting the piston rod from the flame of combustion, this part, internally water-cooled as explained, runs remarkably cool, certainly at a lower temperature than the high pressure piston rod of a superheated steam engine. A hand can be held on the rod during operation at full power. The gland packed with cast-iron rings has given no trouble. The piston rod is of ordinary steel of 28/32 tons per sq. in. tensile strength.

The operation of starting the engine is by electric motor on the starting platform, which drives the starting shaft through worm gearing and the vertical inclined shaft (Figs. 1 and 2). The four positions are: stop, air on the top of the piston, fuel top, and fuel top and bottom. During the first three positions the bottom exhaust valve is held open as already described.

Always a strong feature of the design of marine oil engines by these constructors, the questions of access to the principal parts and of ease of dismantling have been given the greatest attention; accessibility, if not the leading characteristic of this design, has been regarded, and correctly so, as of the very greatest importance.

The bottom combustion chamber can be examined internally by the removal of the door carrying the inclined fuel valve. For lowering away the bottom cylinder cover, the cast-iron plate which separates the crankcase from the cylinder is removed. A tube of light cast iron jointed vertically is bolted round the piston rod, resting on the crosshead. This can be seen in the illustrations, Figs. 5 and 6. The engine is barred round until the top part of this sleeve, which is swelled out to clear the gland, rests against the bottom cylinder cover (Fig. 6). The bolts securing the top and bottom portions of the cylinder together are then removed. Turning the engine crank down lowers the bottom cover until it rests on the crankcase top. The tube around the piston rod is removed, and further turning of the engine brings the piston opposite the gap between the two portions of the cylinder, when the piston can be inspected, rings freed or replaced, or, in fact, the piston itself dismantled from the piston rod and withdrawn as shown in Fig. 5.

As instancing the rapidity of removal of the piston after the successful completion of the 20 days' and nights' full power trial which concluded successfully on the 23rd instant, the dismantling of the engine was commenced at 7.30 a.m. By 9.20 a.m. the first ring was removed, and at 1.15 p.m. the piston was removed. During this trial under observation by leading authorities the engine ran steadily with a clear exhaust, and at the conclusion an opportunity was further afforded of examining the parts as opened up. The cylinder liners were in excellent condition, lubricated and bright, the piston rings were free, and no abnormal carbon deposit was present. The valve faces were good. The piston rod surface showed no signs of distress. As the bearings had run cool and are force-lubricated no appreciable wear need be anticipated.

The leading dimensions of the engine are as follows:—

	Mm.	In.
Cylinder diameter	800	31½
,, stroke	1,400	55
Crankshaft diameter	470	18½
Piston rod ,, ...	250	9⅞
Connecting rod ,, ...	210 to 240	8¼ to 9½

The lay-out and the testing plant is very complete as will be seen in Figs. 1 to 3. For the single cylinder a large flywheel is provided, carried in an outboard bearing of the Michell journal type. The small size of journal for the relatively heavy weight of slightly over 24 tons will be noted from Figs. 2 and 3. A large water-brake absorbs the load. All the auxiliaries are electrically driven, including the air compressor for the injection and starting air. The blast and starting air receivers will be seen in Figs. 1 and 3. The fuel is weighed. Electric heaters are fitted to the fuel tanks for tests on the heavier grades of fuel oil.

It might be thought at first sight that the engine is high for its power. By comparison on site with a wall diagram of a similar steam engine, drawn on the wall, it could be appreciated that the extra height is small and in most types of vessels is not of any moment. Of prime importance, however, is the saving in length of engine. An eight-cylinder single-acting engine can be replaced by a double-acting engine of equal power occupying in length the space of five only of the eight single-acting cylinders.

In conclusion, it can definitely be stated that this design represents a very practical solution to the problem of increasing the power per crank of the marine oil engine. The engine is simple, open and accessible. The results of the trials to date, and the condition of the engine at the conclusion of a non-stop run equivalent to the distance from Colombo to Newcastle in an average ship, augurs extremely well for future success at sea of this type, and indicates clearly that whatever difficulties may arise in the course of evolution towards yet higher powers per crank, they should not prove in any way insuperable or even unreasonably severe.

PORT FACILITIES.

To a nation of our character, whose sons follow the sea, and whose existence in this crowded island is dependent upon outgoing and incoming seaborne trade, the question of port facilities is of a vital nature. Without efficient ports we would simply cease to exist, since we cannot raise here food for more than a fraction of our population, and purchases from abroad must be paid for in some way or other by exports. Inefficiency at the ports means price added to exports on the one hand and to imports on the other. Both count against us, for the former increases the handicap on our goods in the international market, at the present time sufficiently severe as it is, owing to the state of foreign exchanges, and the endeavour here to keep to as high a standard of wages as possible; while the second increases to us directly the cost of necessities which reduced exports would naturally make it more difficult to pay for.

It has been urged, with some truth, that our ports have not been in recent years as efficient as is requisite for the well-being of the nation. When circumstances are recalled, can this be wondered at? For many strenuous years our ports were wholly turned over to the great enterprise in which the nation was engaged abroad. Ordinary export and import trade ceased to exist and emergency conditions prevailed everywhere. The sudden interruption of the arrangements called thus into being, and the reversion to normal trading methods were accompanied by complications due to Government control and de-control, railway re-organisation, inordinately high prices for everything, labour difficulties, and the flash in the pan of road transport, which for a time people thought to be a solution of so many difficulties. In some respects the situation is now improved. The ports are working better and the railways have got their plant and stock practically reconditioned. If it were not for the war legacies in connection with labour we would be comparatively well placed. These, however, severely handicap us still, and the short hours and higher wages, with restrictions, adversely affect endeavours to bring about improvements.

This point is clearly brought out in the report published during the past week by the Port Facilities Committee appointed recently by the Chamber of Shipping of the United Kingdom, the Association of British Chambers of Commerce and the Federation of British Industries. Here attention is drawn to the fact that excellent facilities, provided at the South Wales coal ports, are rendered useless since the benefit due to the economical handling of material which they render possible, is negatived by the objection to the introduction, as unnecessary, of the third shift. It is essential that good facilities should be backed by satisfactory labour at an economic rate; otherwise no advantage may accrue from expenditure on plant and improvement.

To engineers the report will prove interesting in that it shows what is now being done in various directions, as well as what more the Committee considers might be done in these and in others. Dealing with dock and harbour accommodation the use of larger ships makes it desirable to increase the depth of water in docks, &c., and, especially in connection with the Bristol Channel ports, the installation of additional impounding pumps is recommended. Various suggestions are made as to increasing the depth at quays, the provision of new berths, the widening of dock entrances, &c., while generally speaking, the committee recommends open quays and tidal docks for new works, where practicable, owing to reduced cost and their greater accessibility.

With regard to coaling facilities, attention is drawn to the large coaling staithes in use in America, at which cars of 100 or more tons discharge into hoppers which in turn discharge direct into the ship's hold by gravity. Nothing in this country exists comparable with the large coal terminals in the United States. We are glad to note that attention is drawn to the wagon question. There is little doubt, we believe, that a great deal of economy would result, in, for instance, the South Wales district, from the abolition of the private colliery wagon and the general introduction of a larger capacity car for the mine-to-port traffic. This traffic is so great that it should be possible to keep large cars busy on it without trouble and without serious interference with the handling of the smaller wagons of the inland trade. The report recommends the suppression of the colliery owned wagon for port traffic, and the adoption of 20-ton or 40-ton coal cars instead by the railway.

Another recommendation of the Committee is that hydraulic cranes should be abolished in favour of electrically operated appliances. The time was, of course, when in the earlier developments of the electric crane, this machine had some difficulty in proving its claims against the well-established and highly developed hydraulic system. At the present time, however, there is little doubt that electrical plant can do all that, and more than, is required of it at ports, while general considerations of convenience invest it with immense advantages. For new plant electrical machinery would undoubtedly almost invariably be resorted to, save perhaps for one or two special uses, but the scrapping of

effective hydraulic machines is another matter. The Committee's recommendation in this connection are, we believe, restricted, however, to wharf cranes, for which electricity has undeniable claims.

The report is full of interesting points which we cannot deal with effectively now. One further subject may be touched upon, and that is the futility of providing excellent port accommodation and facilities if access thereto is not also on an adequate scale. The report refers to bottle-necks on the railways, while almost equally important in some cases is access by road. Improvements in these directions will certainly cheapen handling by reducing congestion and expediting the shipment or unloading of freight. Broadly speaking, the railway-owned port has an advantage here, as the company should realise the necessity for seconding port development by adequate work behind the scenes and should be well placed for giving effect to the necessary improvements—an easier task for a single body than when co-operation is necessary between several. Upon whom the cost of such works should fall must vary with circumstances, but that it should be entailed admits of no argument.

NOTES.

LORD FISHER'S INSTRUCTIONS FOR THE CONSTRUCTION OF THE "RENOWN" AND "REPULSE."

IN the course of his Watt Anniversary Lecture, at Greenock (see ENGINEERING, page 115 *ante*), Sir Eustace W. H. Tennyson-D'Eyncourt referred to the records established in the construction of battle cruisers by the building of the Renown and the Repulse. We have now received from Sir Eustace a facsimile of the written instructions sent to him as Director of Naval Construction, by Lord Fisher, who was then First Sea Lord, for the preparation of the model to accompany the design drawings, when they were to be examined by the Admiralty Board and the Commander-in-Chief. This letter reads: "Battle cruiser 'Rhadamanthus.' Speed, 32 knots. Six 15-inch guns—Twenty 4-inch automatic guns—all on top deck. (20 deg. elevation. Range ( ) yards) (30 deg. elevation. Range, 14,000 yards)—Armoured like 'Indefatigible'—2 torpedo tubes—All oil—Radius of action at ( ) knots ( ) miles. Freeboard forward, 35 feet, aft ( ) feet. Length, 750 feet—Beam ( ) feet. Dear D'Eyncourt, That's the sort of label to put on the model! I'm sure you'll benefit by 750 instead of 720 feet. Yours, FISHER. 19.12.14." The date is only 11 days after the Falkland Island battle, in which the value of battle cruisers was very markedly demonstrated. On the day of receipt of this note, the designs were actually started, and the keels were laid on January 25, 1915. Details were worked out concurrently with the building, and both ships were finished and put into commission in the early autumn of 1916, or about 20 months after their commencement. It was often remarked by Lord Fisher that Von Spee was not defeated in December, 1914, but in 1906, when the Committee on Designs, over which Lord Fisher presided, determined on the construction of vessels of the Battle Cruiser type. The letter of the great Naval Chief is not only interesting in itself, but it is one further proof of Lord Fisher's usual active procedure. It affords evidence of the desire to make use at the earliest possible time of the valuable information obtained in actual engagements. During the period of his service at the Admiralty, in 1914-15, Lord Fisher put in hand a vast amount of Naval construction, and he pushed forward the work upon it with the greatest energy. The result was the most remarkable achievement in the construction of warships ever seen, and at a rate which had never previously been approached.

ATMOSPHERIC INTERFERENCE IN RADIOTELEGRAPHY.

Describing recent researches on "Atmospheric Interference in Wireless Telegraphy," conducted by the Radio Research Board at Cambridge and Aldershot, Dr. E. V. Appleton, who was assisted by Mr. F. H. Herd, stated in two Royal Institution lectures that near and far thunderstorms could probably explain most of the "atmospherics." An aerial was an oscillator. Any succession of blows would make an elastic rod oscillate; but the oscillations only became of large amplitudes when the periodicity of the blows accorded with the natural period of the rod. So it was with an aerial, and since an aerial of any capacity and inductance responded to all atmospherics, those disturbances must be of the nature of pulses rather than of vibrations. To study the disturbances, the natural period of the aerial should be suppressed by heavy damping. In their experiments with a cathode-ray oscillograph they found that the pulses might be positive or negative and quasi-periodical; the most frequent wave form was a positive peak followed by a smaller negative wave. The potential gradient was only about 0·13 volt per metre; but that was thousands of times stronger than the field strength of a radiotelegraphic signal, and the pulse might last 40 times longer than the signal. Thunderstorms were very common; there might be 1,000 at any moment, all over the earth. According to C. T. R. Wilson, the energy (20 coulombs at 10^9 volts for 1/1,000 second or less) carried by a lightning flash would cost about 30*l.* in England. The discharges might pass between clouds, between a cloud and the earth or between a cloud and the upper conducting layer of the atmosphere, which was sharper defined at night than in day time. The discharges would set up induction waves at starting and stopping; there would be direct waves and waves reflected from the upper layer, and those complex factors might account for the peculiar wave-forms of the disturbances, their time-coincidence over many hundreds of miles, their predominance near sunset and sunrise, and the greater signal strength but diminished reliability of direction finding by radiotelegraphy, at night times. The magnetic field of the earth was probably too weak to be of much influence; yet sending north-south was easier than sending east-west, and direction errors were less serious with signals in that direction.

A NEW LANCASHIRE POWER STATION.

To meet the increasing demands for electricity in Lancashire, the Lancashire Electric Power Company and the Corporation of Burnley each prepared a scheme involving the construction of a new generating station, the company proposing to build one at Padiham, and the Corporation at Simonstone, both in the neighbourhood of Burnley. In accordance with the regulations of the Electricity Supply Acts, the schemes had to be adjudicated upon by the Electricity Commissioners, who therefore opened a Local Enquiry into the matter at Burnley on February 27 last. After a full consideration of the evidence brought forward on each side, the Commissioners have decided that the scheme of the Lancashire Electric Power Company is more favourable to the general supply of electricity in the mid-Lancashire district, and have therefore given their consent to the new station at Padiham. Their reasons for this decision are fully set out in the report just issued, and appear conclusive. Each applicant had expressed willingness to give a bulk supply to the other at rates based on the scheme for bulk supply charges formulated by the Engineering Advisory Committee for S.E. Lancashire. The Commissioners were satisfied that the construction of a station by the Power Company at Padiham would enable both the company and the Corporation to supply their respective customers more cheaply than if a station were built by the Corporation at Simonstone. An obligation will be imposed upon the Company to give any necessary bulk supplies to local authorities at prices no greater than those formulated by the Engineering Advisory Committee, and restrictions are further placed upon them in respect of the heating of the river Calder by the discharge of condensing water. It may be mentioned that the present power station of the Lancashire Electric Power Company at Radcliffe ranks as about the third in Great Britain as regards lowness of fuel consumption per unit of electricity delivered. Considering that the boiler pressure is only 160 lb. per square inch, and the steam temperature only 520 deg. F., the performance represents an efficiency of operation probably unequalled. With similar operating methods and more modern boiler-house equipment, Mr. Adams should obtain results at Padiham comparable with those of any station in the world. The new Barton station of the Manchester Corporation, we believe, now holds the world's record for overall thermal efficiency, and an interesting rivalry between these two Lancashire plants is to be anticipated.

TRANSATLANTIC WIRELESS TELEPHONY.

It will probably be remembered that, in January of last year, some important experiments in long-distance wireless telephony were carried out at the New Southgate works of the Western Electric Company, Limited, where, as the result of investigations made by the American Telephone and Telegraph Company and the Radio Corporation of America, speech delivered in New York was successfully received. The experiments were described on page 80 of our 115th volume, and further particulars of the system employed, given by Dr. H. W. Nichols of the Western Electric Company's physical research department in a lecture before the Institution of Electrical Engineers, will be found on page 272 of the same volume. The essential feature of the system was the suppression, at the transmitting end, of the carrier wave and one of the two side bands, and the transmission of one side band only, the carrier wave being re-introduced at the receiving end by means of a local oscillating circuit. The system has several advantages, of which the more important are the reduction of interference with other systems and the reduction in the power required effectively to cover a given distance. As a result of the experiments, the Postmaster-General, in April, 1923, appointed a committee, under the chairmanship of Admiral Sir Henry Jackson, to consider the possibility of Transatlantic wireless telephony on a commercial scale. In the meantime the experiments were continued by the three companies mentioned above, and additional experiments were carried out on behalf of the committee by the Post Office Engineering Department, with a view to obtaining further data for the construction of more powerful apparatus. Telephonic transmissions have taken place weekly from the Long Island station and, under favourable conditions, the received speech has been distributed over land lines to telephone subscribers in London and in other parts of the country. The success achieved in these telephonic transmissions from America has been sufficient to justify the committee in recommending the Postmaster-General to install a 200 kw. transmitting set of the type referred to, at the new Post Office wireless station at Rugby, so that two-way conversations can be carried on. It is hoped that, with this apparatus, it will be possible to connect telephone subscribers in London with subscribers in New York when atmospheric conditions are favourable, as is usually the case during the winter months. The plant will also supply the data necessary to determine whether it would be possible to establish a regular and reliable telephone service between the two countries, since it is hardly necessary to point out that a wide gulf exists between a service that can be operated under favourable conditions only and one which can be used at all times. The latter, however, appears to be well within the bounds of possibility, whereas we believe it would be quite impracticable with any existing type of submarine cable.

THE GOVERNMENT AIRSHIP POLICY.

As announced by the Secretary of State for Air in the House of Lords on the 21st instant, the Government have now rejected the Burney Airship Scheme and adopted in the place of it a scheme of their own. In accordance with the latter it is proposed that the Air Ministry shall proceed with airship research work, using one of the existing ships, and shall also construct at Cardington an airship of 5,000,000 cubic ft. capacity. This vessel, we gather, will be designed with a view to service requirements, but another vessel of the same capacity, the contract for the construction of which will be offered to the interests represented by Commander Burney, is to be constructed for purely commercial purposes. The data available from the research work of the Air Ministry are to be placed at the disposal of Commander Burney, from whom the Government also expect to derive some useful information in exchange. Another point is that provision will be made for the Burney interests to take over the commercial ship at a reduced price,

if they should require it, for the operation of an Imperial commercial service. It thus appears that some attempt is now to be made to develop airships in this country, but we should hardly like to hazard a guess at the probable date at which an efficient commercial airship service will be in operation between this country and India or Australia under the Government scheme. Such a service, which would be of the utmost value to the Empire, was at least probable under the Burney proposals, and, as we think, will only be achieved by private enterprise with financial and other assistance from the State in the early stages. As mentioned on page 342, *ante*, no provision for airship development was made in the current air estimates, but a supplementary estimate for 350,000*l.* was issued on the 23rd instant and agreed to by the House on Wednesday last. Of the sum voted, 150,000*l.* is for airship construction and the remainder for development work. The total expenditure on airships for the current and the next two financial years is provisionally estimated as not to exceed 1,200,000*l.* net. In connection with the supplementary estimates, a note by the Secretary of State for Air was published on Tuesday last giving the principal terms of the contract it is proposed to offer to the Airship Guarantee Company, Ltd., for the construction of the commercial airship above referred to. The agreed price for the vessel is 300,000*l.*, but an additional payment of 50,000*l.* will be made as a contribution to the contractors' capital expenditure. The main technical requirements are that the gas capacity shall not be less than 5,000,000 cubic ft., a speed of not less than 70 miles per hour at an altitude of 5,000 ft. shall be attained on trials, and the fixed weights shall not exceed 90 tons. The vessel must also comply with the general requirements of the Aeronautical Research Committee with respect to airworthiness, but, subject to these and to some other conditions, the company are to be given a free hand in the design and execution of the work. The prescribed trials will include a voyage to India as well as tests in this country. No time limit for the completion of the contract vessel appears to have been imposed, but it will be laid down simultaneously with the Government built ship.

CHEMISTRY, GAS AND REFRACTORIES AT THE BRITISH EMPIRE EXHIBITION.

IN the article on chemistry and gas at the British Empire Exhibition, on page 646 *ante*, we limited ourselves to exhibits of these sections in the Palace of Industries. Many of the exhibits in the Palace of Engineering call for notice under the same headings. If the difficulty in the Palace of Industries was to select matters of interest to the engineers from the manifold display of chemical products, there is in the Palace of Engineering still wider overlapping of the engineering and chemical divisions. Iron and coal, coal mining and carbonisation, gas and tar production and by-products recovery go together at Wembley as they do in the plants and works, and some of the firms also supply the refractories which are indispensable to them. Supplementing to-day our comments on chemicals and gas and their applications, we shall briefly have to mention some firms whose other productions have been, or will be, described on other occasions.

Fuels for special purposes can be seen on several stands, but there is little that claims novelty. The Amalgamated Anthracite Collieries, Limited, of Westminster, draw attention to the fact that the minor explosions of anthracite in stoves, which have recently caused some alarm, have been traced down to portions of unexploded cartridges of a certain, now discarded explosive. Extensive researches* have been made in the matter, and further accidents need not be feared. The anthracite briquettes for domestic and other use, of the Polmaise Patent Fuel Company are shown on the stand of Messrs. D. Colville and Sons, of Glasgow. In the joint exhibits of the Cargo Fleet Company, Messrs. Cochrane and Co., of Middlesbrough, and the South Durham Steel and Iron Company, tar products are displayed in an imposing enclosure formed by the Lackawanna rolled-steel piling of the first-named firm and the concrete-lined steel pipes and the socket and spigot concrete pipes (Vianini type) of the second firm. A highly-polished coating of a hydrocarbon composition, impervious to water acids and alkalis, is centrifugally applied to the pipes.

The Consett Iron Company, of Durham, make silica bricks for gas benches at their Templeton works from the ganister mined in West Butsfield. The bricks are burnt at 1500 deg. C. to convert all the quartz into cristobalite and tridymite to avoid permanent and after-expansion, and the bricks are joined by the Consett silica cement which has the same silica contents (95 to 97·6 per cent.) as the bricks. Conspicuous among the exhibits are a segmented silica retort and a large section of the new battery for the Fell By-Product Works, the 3,800 tons of silica shapes of which were built without cutting a single shape. For cupola linings the firm recommend their Delves fire clays, containing from 30 to 40 per cent. of alumina.

Messrs. Guest, Keen and Nettlefold, of Smethwick, with whom Messrs. Guéret and Co., of Cardiff, are associated, limit their exhibits of refractories to sleeves, nozzles and stoppers of ladles and to muffles; some of their "Anchor" briquettes on view have recently been found by the Admiralty to be as good as they were thirty years ago. Tar products and sections of tarred-slag roads are exhibited by the Partington Steel and Iron Company (associated with Sir W. G. Armstrong, Whitworth and Co.), and the Staveley Coal and Iron Company, of Chesterfield. A block of cannel coal from the Maypole Pit at Wigan of the former company, can be lighted by a match in a few seconds. The other firm submits its slags, immersed in tar, to a special toughening process; the "Staveho" shown is a powder which is mixed with dry cement to make it waterproof, and the caustic soda and bleach of the firm are electrolytic. As regards anti-corrosive paints and enamels we should also mention the "bitumastic" of Messrs. Wailes Dove Bitumastic, Limited, of Newcastle-on-Tyne; it is applied as a bright black (also red and green) coating to iron structures, bridges, roofs, floating docks, &c. The "Foliac" of the Graphite Products, Ltd., of 218, Queens Road, S.W. 8, a pure flake graphite preparation, not of the finest subdivision realisable, is recommended as a lubricant, paint and as a waterproof graphite grease; the latter is applied to the dry surfaces by the K & W graphiter of the firm.

Two well-known Glasgow firms specialising in fireclay refractories, the Glenboig Union Fire Company and Messrs. Peter Hurll and Mark, have some of their works at Glenboig, in Scotland, and their products—seamless retorts for gas and chemicals, traps, bends and inspection pipes, displayed in great variety, are distinguished by the same yellowish-brown tint.

The natural refractory and insulator, asbestos, is well represented in its various adaptations by several old-established firms. The Turner Brothers Asbestos Company, of Rochdale, has covered the concrete columns of the Stadium and the roofs of the Palaces of Engineering and of Industries and Art with Turners' Trafford tiles, which had previously been found in tests to bear loads of 2,000 lb. on 3 ft. 6 in. spans. At the stand, asbestos packings, cloth jointings, &c., can be seen in all varieties, including the imitation wood panelling, consisting of a veneer of oak applied to asbestos. Newall's Insulation Company, associated with Messrs. Turner, combines asbestos with other insulating materials, magnesia and cork. Part of the stand of the firm is tastefully arranged to represent a section of a ship to show cabins, uptakes, &c., with brilliant white coverings consisting of magnesia slabs secured by expanded metal to the steel structure and finished with a special hard cement surface. The Newall magnesia contains 85 per cent. of magnesium carbonate and 15 per cent. of long-fibre asbestos, and is used also as plastic covering. For cold-storage insulators the company recommends its Nonpareil cork. Magnesia may be obtained from dolomite (magnesium and calcium carbonate) by various processes based upon the fact that when dolomite is treated with carbon dioxide the magnesium carbonate passes into solution before the calcium salt is attacked.

Similar aspects of the use of asbestos and magnesia insulation in the engine room and on board are exemplified by Messrs. Hobdell, Way and Company, of London, E.C. There we find also an imitation oak-panel room, Hobsil bricks and Achilles asbestos mattresses and further the "Petroflex" feed pipes for petrol and oil. These pipes, sections of which are united by the aid of copper sleeves and flanges, without straps, consist of several layers of asbestos and fibre and an outer and an inner spiral of wire; in large pipes, which resemble armoured cables, the outer wire is replaced by hoops. Messrs. Reed, McFarlane and Company, of Govan, should also be mentioned for their asbestos and cork heat-insulation appliances.

The Thermal Syndicate, Limited, of Westminster, exhibits its remarkable fused silica "'Vitreosil," transparent and opaque, for physical and chemical apparatus, radio valves, acid concentration, &c. The Vitreosil gas globes shown in the Building and Lighting Section of the Palace of Industry will bear a cold-water spray when red hot.

One of the novel applications of the metal-spraying process by means of the Schoop pistol, fed with hydrogen and oxygen, or with coal gas and oxygen, which are being demonstrated by Metallisation, Limited, of Albemarle Street, W., is the coating of fire bars. The bars are heated, before being sprayed with aluminium, and afterwards heated to a higher temperature; only the upper portion of the bar, in contact with the fuel, requires this treatment, which is said to make the bars last considerably longer than untreated bars; retorts, baffles of locomotive boilers, &c., are similarly treated. The process differs from the American "calorising," which requires heating of the iron together with aluminium dust to much higher temperatures. The material to be metallised is first sand-blasted. Aluminium castings are coated with zinc to prevent corrosion by sea water; metal spraying is frequently used to fill up pores or to obtain smooth surfaces; a rustless iron coating is produced by spraying chrome steel.

Gas-making and gas-producers are not conspicuous in the Engineering Palace, nor in the Exhibition generally. In the Palace of Industry the British Empire Gas Exhibit Committee has concentrated its attention upon applications of gas and upon by-products. In the Engineering Palace we have not found any gas-producers provided with mechanical agitators, and coke-oven plants seem only to be exhibited in models by the Semet-Solvay and Piette Coke Oven Company, of Sheffield. The company builds Piette waste-heat ovens of the vertical flue type, with two longitudinal waste heat collecting flues, and Semet-Solvay ovens of the horizontal heating-flue type without and with reversing arrangements. A half-size model of a section of the reversing regenerative type, with vertical flues, all in silica brick with silica cement joints, is one of the exhibits; the carbonising space is of tapering width, 15 in. to 13 in., 40 ft. long and 16 ft. high. The other large model of a complete Piette low-power gas oven is so modified that it can be heated with either producer or blast furnace gas or with coke-oven gas; the alterations required for the different fuels are limited to the hearth level and the preheating of the fuel gas; when coke-oven gas is to be used, the change can be made in a few minutes by manipulating certain dampers and cocks. Semet-Solvay regenerative reversing coke-ovens are now under construction for Messrs. Bolckow Vaughan and Company, and at the South Yorkshire Chemical Works. The company has also taken up the hot-coke dry-quenching process of Messrs. Sulzer Brothers, which we described on page 355 of our issue of September 15, 1922.

The suction-gas producer exhibited by Messrs. T. H. and J. Daniels, of Stroud, is a 25-h.p. producer for anthracite, wood or charcoal, of the approved type, such as the firm builds, in sizes up to 200-h.p. The producer is provided with two scrubbers; the gas pipe is water-jacketed, and the evaporator is on top, underneath the hopper.

The National Gas Engine Company, of Ashton-under-Lyne, shows, in addition to a three-cylinder four-cycle vertical gas-engine and other engines, models of two novel modifications of their suction-

* Messrs. Illingworth, Seyler and Wheeler found that pellets of a gelatinised explosive, closely resembling coal in appearance, were able to pass through the crushers, the washery and the screens; the accidents occurred in the winter of 1922–23, and again last winter, the latter cases occurred, apparently, with old coal stock.

gas producers, one for wood, the other for various fuels, to which we hope to refer on another occasion. The firm also exhibits the new Widlake distant pressure indicators, the invention of Mr. H. C. Widlake, which are made by the Gas Light and Coke Company of Plymouth. At each key station of a gas distribution plant on this system there is provided a gauge which a circuit line leased from the General Post Office connects with a battery and an indicating voltmeter at the works. The gauge is a cylinder partly filled with oil, on which a mercury tray floats; the gas pressing on the oil raises the float. In the upper portion of the gauge are mounted a dozen or more vertical wires, partly covered with insulation and bared to different lengths. The mercury closes the circuit through one of the wires, and the resistance in circuit varies with the momentary gas pressure. The meter is calibrated in units of gas pressure.

The Parker Producer Gas Plant Company, of Conduit Street, W., shows a model of one of their producers and the chassis of a lorry, complete with engine and a new modification of this producer, especially adapted to charcoal fuel. The producer is a vertical cylinder. The fire-box, 1½ ft. in diameter, is overtopped by the hopper, the total height being 3½ ft: The fire-box is lined with a chromite preparation. The air enters a square box half-way up the producer and travels in the jacket between the steel wall of the fire-box and the casing, down to the grate, which is pivoted, and then upward. Steam is supplied from an annular trough in the grate. The gas passes through a pipe which is taken right round the chassis and back to the scrubber, which, like the producer, is mounted in the front portion of the lorry. The distinctive feature is the single scrubber. The producer for a 40-h.p. motor weighs 3½ cwt.

Passing to gas applications and the regulation of gas supply, we may mention the apparatus of British Arca Regulators, Limited, of Westminster, which we deal with in detail elsewhere in this issue. The atomisers of the Aerograph Company, Limited, of Holborn Viaduct, serve for paint-spraying and especially also for the oil-spraying of gas pipes with the object of preventing the internal corrosion of the pipes and the deposition of napthalene. The atomiser is introduced into the pipe to inject the oil in the direction of the gas flow through a needle valve. This is done either at the works, in the gas outlet, or by means of portable compressors at other points. The oil excess is subsequently syphoned off.

In the drip-proof gas rings of the J. Keith Blackman Company, Limited, of Farringdon Avenue, E.C., each burner is a tubular nozzle provided with a projecting conical roof and horizontal gas ports, and is set in a hole of a plate of refractory material lying on the ring. The jet flames are deflected upward and heat the refractory, and any boiler scale or dirt dropping from above falls on the roof and further down without clogging the burner holes. For blow-pipes, several radially-convergent burners are so arranged that a long tongue of flame is produced; in another arrangement the gas escapes through a vertical slit. Soldering irons, flat irons, and centrifugal blowers are also modified for efficient heating by high-pressure gas. The gas-fired air heater of the firm for hot air supply on the regenerative principle, is somewhat novel. A large vertical cylinder is divided into eight segmental compartments under which a number of burners are revolved at about 1 r.p.m., two compartments being heated at the time; the compartments contain a heat-absorbing material (asbestos). The air to be heated is drawn down through two diametrically-opposite compartments and takes up the heat before passing out; the combustion products are kept separate from the air-feed.

The new exhibits of Messrs. James Stott and Co., of Oldham, are, like their gas regulators, mainly designed to secure quick service and efficiency without avoidable waste of gas fuel. One form of the Stott gas boiler gives only boiling, *i.e.*, not merely hot water. When the gas is turned on by hand, the water tap is also opened and the water flows into the top of the cylindrical copper boiler, being discharged into an over-flow tray to pass down and to be heated by the ring burner underneath the boiler. The steam pressure raises a float, which takes up a large portion of the boiler space and controls the water and gas feeds. The "Thermofeed" regulator and "Guardian" water alarm of Messrs. Ronald Trist and Co., of Clipstone-street, W., also employ float valves, but their action depends upon the height of the water in the boiler, and not upon steam pressure or temperature. In the water alarm two buckets are mounted on a spindle, which carries a valve. Both the buckets are normally full of water; the lower bucket is submerged in the float chamber, and the upper bucket depresses a pawl. When the water level falls or rises beyond certain limits, the altered buoyancy of the device opens the valve and blows a whistle.

For their coast-lighting equipment of light-ships, beacons, and buoys the Patent Lighting Company, of New Broad-street, E.C., makes use of oil gas, and of acetylene dissolved in acetone, both compressed to 10 atmospheres; low-pressure acetylene is too apt to clog the burners with sooty carbon. The usual type of burner is Y-shaped; the brass pilot flame tube lies horizontally in the fork and the upper portion of the tube is cut away. Oblique air inlets meet the gas port in both arms of the fork; when several burners are combined in one lamp one pilot suffices for the lamp. The regulation of flash-lights is—except for light-houses—effected by the gas pressure through the intermediation of a leather diaphragm and springs and levers. In oil-gas installations the buoy is the gas container; with acetylene lighting the buoy serves as platform for the gas cylinder. In addition to a great variety of these well-known lamps and accessories and to the noiseless, low-current electric ventilating fans for railways and ships the company exhibits a model of a new production of theirs, the "Ventimotor," an inexpensive wind-power motor especially designed for electric lighting for country houses. A two-blade wheel is mounted on the top of a wooden upright, 16 ft. high, driving a small dynamo directly; by means of a counterpoised pilot-plate and a governor fin the device is turned about its vertical axis when the wind becomes too strong.

We finally come to oxygen. The British Oxygen Company makes a special feature of the universal oxy-coal gas and oxy-acetylene metal-cutting machines, which we have noticed, and of high compressors and pressure valves as manufactured in the Upper Edmonton works of the firm. Attention is also drawn to the Spa-radium bulbs which are supplied by Messrs. Sparklets, Limited, of the same address, and displayed in one of the kiosks; the bulbs, of sparklet type, contain liquid carbon dioxide or oxygen and some radium salt, said to be of medicinal value.

The chief novelty of the Hydrogen, Oxygen and Plant Company and of the associated Liquid Oxygen Explosives, Limited, of Albemarle-street, W., are the Weber liquid oxygen cartridges, recommended for blasting in all (except fiery) mines. The cartridges are simply brown-paper cases filled with sawdust. The portable liquid oxygen container, of brass, is a thermos flask (double-walled); the inner cylinder containing the liquid oxygen is surrounded by the cartridges, which, on the spot, are dipped into the liquid, and then inserted into the holes, one or several cartridges (up to 16) in series, and tamped with loam or sand after fixing the Bickford cord or detonator, or both. One cartridge, 19 in. long, 2 in. diameter, is considered equivalent to 2¼ lb. of dynamite, and the oxygen blasting is said to be cheaper. In cases when even the use of the portable oxygen plants of the firms would not be advisable, and oxygen cylinders are not obtainable, oxylithe or oxygenite are recommended. Oxylithe is sodium peroxide, a grey powder which generates oxygen when in contact with water. The generator also resembles a thermos flask, and contains three cylinders fitting into one another; the inner cylinder, which has a perforated bottom, is charged with the cakes of oxylithe; the water is in the outer cylinder; 1 lb. of oxylithe yields 2¾ cubic ft. of oxygen. Oxygenite is a powdery mixture of potassium perchlorate (electrolytically prepared) and some siliceous material in the ratio of 80 : 20; 1 lb. gives 4½ cubic ft. of oxygen when heated by means of an "igniter." The generator is a strong iron vessel with screwed-down cover; the oxygenite is charged into an inner cylinder. When the igniter has been inserted into the upper portion of the oxygenite and has been lighted by a match, the cover is quickly screwed down; the oxygen liberated is washed by passing through water in the generator. The firms also supply dissolved acetylene, which they purify by means of their "Epuratol." They also have exhibits of their welding and metal-cutting outfits.

LITERATURE.

The Metallurgy of Steel. Two Vols., each complete in itself. Vol. I. *Metallurgy*, by F. W. HARBORD; Vol. II. *Mechanical Treatment*, by J. W. HALL. Seventh Edition thoroughly revised. London: Charles Griffin and Co., Limited. [Price 32*s.* net each vol.]

THIS standard work on steel, has again appeared in an enlarged and excellently-revised edition. The authors are to be congratulated on their work. The revision and enlargement have not only extended to the inclusion of subject matter on recent researches on steel and development of works' practice, but also to the addition of a new and most interesting chapter on the past and future of the steel trade. We trust that this absorbing chapter will be greatly extended in future editions, even should it necessitate separate issue as Vol. III., The Economics of the Steel Trade.

The chapter describes the resources and rise of the industry in the leading countries, paying attention to conditions peculiar to each, such as special metallurgical factors, development of groups and trusts, and political influences. Controversial matters are dealt with in a very fair manner. The future is speculated on, and the settings for the contest for the position of second largest producer are sketched out. The difficulties of the French-German position are indicated. The inevitable way of settlement seems to be a steelmaking aggregate, using Ruhr coke and the minettes of the French North-east. The practicable feasible means will probably consist in French representation on the directorates of the German heavy industries, and some joint exporting scheme. This combination would attain and maintain the second place without difficulty. The British position is frankly discussed, and the strain is optimistic. The conclusions seem to be these: (1) There is no inherent natural reason why France and Germany should be able to export iron or steel cheaper than this country; (2) The importance of cheap coal; (3) The abandonment of trade union regulations, so that a greater output of steel is obtained per man employed. But greater efficiency in the production and use of heat and power in the works would, to some extent, cope with more expensive fuels. The greater output per man per year quoted for America and Germany is bound up with the relative specialisation and mechanicalisation of the works. It probably indicates a lesser degree of craftsmanship, a more sensitive organisation, and greater units. None of these can be considered altogether as unmixed blessings, although the present trend of industrial development renders them almost inevitable. A table showing the proportion of "technologists" on the steelworks staffs in the leading countries, would be illuminating.

Turning now to the main subject of the volumes, the descriptive matter on the manufacture of steel, on the furnaces and appliances used, and on the reactions involved, is excellent. The chapters dealing with the reactions of the Bessemer and open-hearth processes and their derivatives, and of gas-producers and their efficiencies are very valuable. The planning, general arrangment, and mechanical equipment is well treated, but not quite to the same degree as the foregoing. These are matters of great importance as is the efficiency with which heat is generated, moved and used in the various processes. It seems necessary to follow the Continental practice and create within the works a special thermal department, to control all the thermal efficiencies by continual experimental and statistical means, setting up working standards to be raised with increased knowledge. The thermal control station would cost only a fraction of the heat bill, and providing it were adequate could not fail to promote efficiency. Works in possession of such thermal information are in a far better position to employ mixed gases, blast furnace and coke oven,

powdered coal, tar and oil firing as a policy or in case of sudden necessity. The possibilities or use of rich air in steel furnaces is not discussed.

Oxygen plays an important part in the furnace reactions and in the finished product. Fortunately its analytic determination in steel has now become simpler and more accurate. Routine oxygen determinations are the order of the day at some steelworks. The exchange and correlation of information will eventually clarify and establish the effects of this element. Routine pyrometric observations in the same manner are illuminating the effects of temperature on reactions. The behaviour of manganese is now more clearly realised. The complete elimination of inclusions has not yet been attained, although the factors governing their incidence are now soundly established. The electrically-heated ladle, energised perhaps with high frequency currents, seems the most promising route of advance towards degasification and complete freedom from inclusions. Direct steelmaking processes, like the carbon gas cell for electricity, are always fascinating, and a chapter is allotted to them. Reference is not, however, made to the Bassett process, which caused such a stir in 1921. Little is heard to-day of this process employing a rotating kiln, melting heath and powdered coal firing. Wuest's criticism—that the claim to burn the powdered coal to carbon monoxide alone could hardly be established, as neither the requisite temperatures nor quantities of heat would become available without formation of carbon dioxide—seemed sound. But in the latter case oxidation and loss of iron would occur, and incomplete utilisation of the ores. The equipment and working costs could not be confirmed. The sections on mechanical testing, constitution and microstructure, heat treatment, special steels and specifications have been extended. It is hoped that space can be found in future editions for lengthier reference to notched bar tests and their significance.

Vol. II on mechanical treatment is very good. The descriptions of mill and forge plant are excellent, and the chapter on special mills repays careful study. Theories of the rolling and forging processes are touched on, but perhaps hardly as deeply as recently published work would allow. Tubes and bottles for compressed gases are also considered; the growing importance of large seamless hollow bodies for a variety of purposes warrants further matter on the technique of their production.

The generation of power is carefully surveyed and criticised. It seems that neither uniformity nor finality has been reached in this domain. Quite apart from considerations of thermal efficiency, questions of ground space, water available, community of interest with builders of a certain type of prime mover may be the determining factor in a selection. The production and storage of heat and power will probably become more interwoven—blast furnace or producer gas for the coke ovens; blast furnace gas enriched with coke oven gas for the steel furnaces; surplus blast furnace gas in gas engines for the generation of electricity; mills electrically driven. The problems will then be to maintain or absorb supply in the event of dislocation to any member of such an organisation. Shaft producers, tapping their ash as slag would serve as standbys to replace blast furnace gas; interconnection with public electricity supply schemes, would absorb the week-end energy; as would large electric furnaces producing alloy steels from partly refined metal from a tilting open hearth. The gas turbine, if it ever comes, using a gas whose quantity and richness could be varied with the load, as suggested by Holzwarth, would assist in a general solution of the problems, especially if low temperature carbonisation of coals eventually prevail. The bibliography which follows each chapter is a very valuable feature of the latter book. The continuous and happy extension of this treatise is an indication, both of the healthy state of this very important branch of technology and of the debt we owe to these authors.

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THE LATE SIR HENRY HUMPHREYS.—The death took place on Tuesday, May 27, at Devonport, of Engineer Rear-Admiral Sir Henry Humphreys, K.C.M.G. He was the son of Major D. Humphreys, R.A., and entered the Royal Navy as an assistant engineer in 1885. On being promoted to engineer in 1889 he joined the Warspite. From 1895 to 1898 he was senior engineer at Halifax Dockyard. While in this post he was awarded the medal of the Royal Humane Society for saving the life of a workman who was badly injured, and thrown into the water when a dockyard crane gave way. From service as chief engineer on the torpedo boat Speedy he was promoted in 1902 engineer-commander and appointed to the Vulcan. Later he was selected as Admiralty Engineer Overseer at the works of Messrs John Brown and Co. at Clydebank and supervised the construction of the Inflexible and afterwards was appointed for duty on the ship in the Home Fleet. In 1911 he was promoted to the rank of engineer-captain and became engineer overseer at the Fairfield Yard at Govan. At the end of another two years he was appointed engineer officer on the staff of Admiral Sir Berkeley Milne, Commander-in-Chief in the Mediterranean. In 1915 he was Chief Engineer on Admiral de Robeck's staff and was commended for service in action at Gallipoli and received the C.B. Later he went to Scapa and remained there until his promotion to Engineer Rear-Admiral. His last appointment was as chief engineer at Devonport which he gave up on retirement in April, 1921. For long and distinguished service he was awarded the K.C.M.G. in 1919.

LETTER TO THE EDITOR.

"THE TRANSVERTER."

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to your correspondent, "Chartered," I would say that it is easy to ignore the difference between 96 per cent. and 99 per cent., but the whole question of large economies on big generating systems depends on watching not so much the pounds as the *pence*. We are coming in the very near future to transmissions of 100,000 kw., and a 6 per cent. overall difference in efficiency will mean 35,000*l.* per annum wasted, which would keep a good many families from starvation; or, capitalised, would mean over 700,000*l.*

In order, however, to be absolutely fair to the transverter, let us consider what might be gained if it could be increased in size to, say, 10,000 kw. I make bold to say, that, with the increased commutator friction, the efficiency will be at best, about 97 per cent., and the step-down sets must still be in relatively small units and will, therefore, keep at 96 per cent.

Now consider the commutator question. The output of each commutator is increased from 200 kw. (at 10,000 volts) to 1,000 kw. This will certainly involve very considerable increments, both in length and in diameter; and, as the *power* on each commutator is increased, so will the troubles increase when a commutator flashes over. It remains to be seen in practice what will happen when a short-circuit develops on the H.T. system. "Chartered" talks rather glibly about surges; but who told him they would be confined to the A.C. system With D.C., all the protective effect of external inductance is lost and, directly the current suddenly changes, all the various effects of capacitance will manifest themselves, to the destruction of the commutators and probably of the small transformer windings. It is pretty certain that, if transverters of 10,000 kw. capacity be made, the transformers will have to be separated from the commutators and put into proper cubicles. Then the difficulty of the 360 connections per machine, with 100,000 volts between some of them, will be appreciated.

Coming now to your correspondent's point about two cables being wanted instead of three, he omits to state that the total quantity of copper is substantially the same; it is only on the insulators that there will be a saving.

As regards "Chartered's" last paragraph, may I suggest that the profits arising out of the sale of a dozen 2,000 kw. transverters would well cover the initial outlay on experiments; but the makers *would not have touched the fringe* of the market which there is open for a successful competitor with the static transformer. Hence, it does not dispose of the question of *cost* to take up this line of argument.

I willingly concede to Messrs. The English Electric Company all the credit due to their far-sightedness in finding the capital necessary for exploiting so radical and promising an invention. I wish there were more British firms like them!

I am, Sir, your obedient Servant,
A. M. TAYLOR, Major.

"Slade Lodge," Erdington, Birmingham.
May 24, 1924.

POWER STATION IN THE BELGIAN CONGO.—The Belgian Ministry of Colonies, Brussels, is calling for tenders to be presented by June 3 for the supply and installation of a power-station and distribution system at Stanley-Pool, Belgian Congo. A copy of the specification relative to the scheme and a copy of the general specification of May 10, 1916, containing the principal conditions governing the contract, are available for inspection at the Department of Overseas Trade (Room 52), 35, Old Queen-street, S.W.1.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—A visit of the members of this Institution to the National Physical Laboratory, Teddington, has been arranged for Wednesday next, the 4th proximo, at 3 p.m. Friends of members and others interested are invited to attend, but are requested to notify the Secretary of the Institution, Mr. L. Howard-Flanders, 60, Chancery-lane, W.C.2, of their intention to be present. A similar visit to the Croydon Aerodrome, on Saturday, July 5, has also been arranged by the courtesy of Messrs. Imperial Airways, Limited.

CENTRIFUGAL PUMP FOR WELLINGTON, NEW ZEALAND.—H.M. Trade Commissioner at Wellington, reports that the City Council are inviting tenders for the supply and delivery of one electrically-driven multi-stage turbine pump complete with all accessories for the Korori Water Supply Works. Tenders, accompanied by a deposit of 20*l.*, will be received by the Town Clerk, Town Clerk's Office, Wellington, New Zealand, up to 5.30 p.m. on Thursday, August 14. Local representation is essential. United Kingdom firms in a position to supply British materials can obtain further particulars regarding this call for tenders on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1., quoting reference AX 1001.

WILD-BARFIELD ELECTRIC HARDENING AND TEMPERING FURNACES.

CONSTRUCTED BY MESSRS. AUTOMATIC AND ELECTRIC FURNACES, LIMITED, ENGINEERS, LONDON.

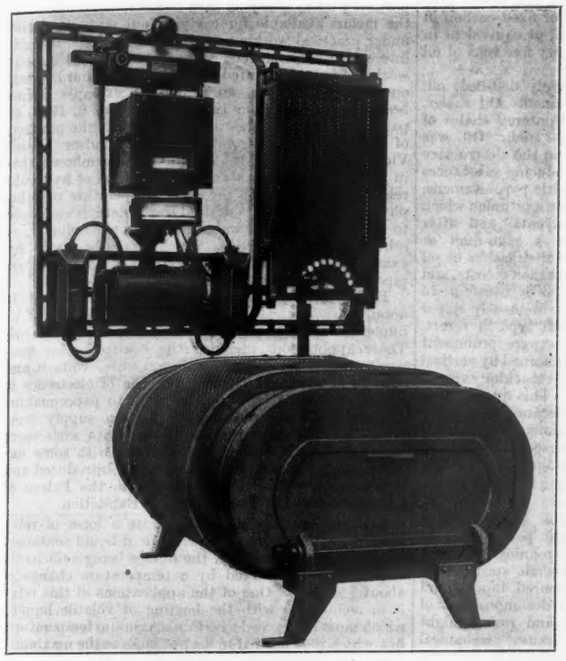


FIG. 1.

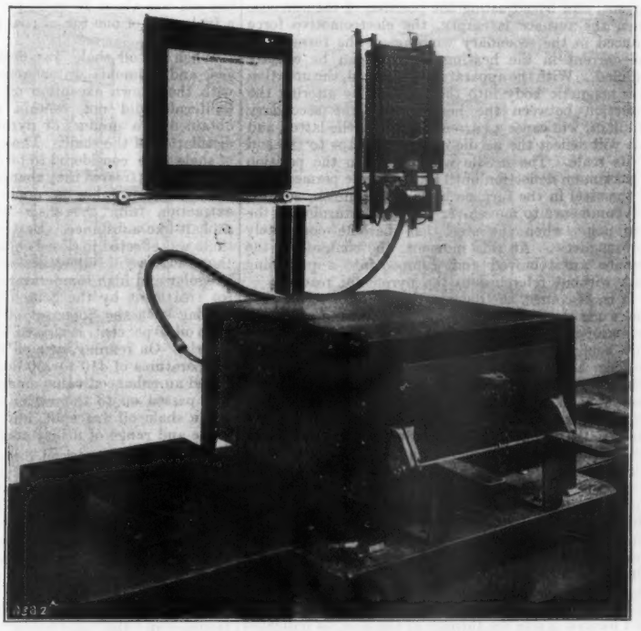


FIG. 3.

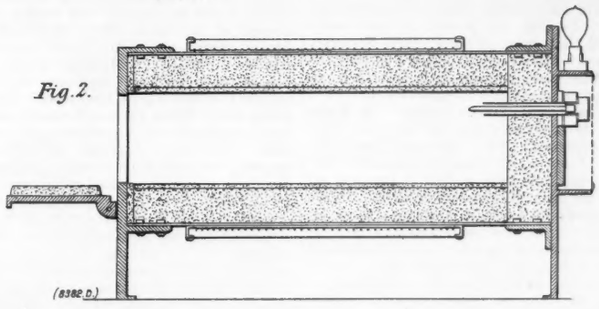


Fig. 2.

FIG. 2.

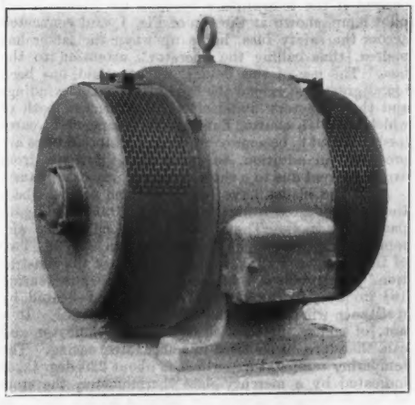


FIG. 4.

ELECTRIC FURNACES FOR THE HEAT TREATMENT OF RAZOR BLADES.

No one who has occasion to use a razor of any type will doubt the necessity for the employment by the manufacturer both of the best quality of steel for forming the blade and of the most scrupulous care in the methods of treating it. All too frequently the razor fails to retain the keen edge which is essential to its satisfactory use, and the failure is generally attributed to the quality of the steel. This, however, is by no means always at fault. Quite commonly the cause of the poor results obtained in service is to be found in the heat treatment applied to the steel. To obtain the necessary fine-grain structure, which is accompanied by the maximum strength and toughness upon which the ability of the blade to take and retain a keen cutting edge depends, the steel must be quenched in the hardening process from the precise temperature at which the whole of the cementite and ferrite coalesce to form a solid solution. If quenched from a higher temperature, a comparatively coarse structure will be obtained and although the hardness may not be greatly affected, the strength and toughness will be reduced. Too low a quenching temperature, on the other hand, results in the development of soft spots and a general irregularity of structure.

In the case of a fairly high-carbon steel, such as is used for razor blades, the formation of the solid solution above referred to is accompanied by the absorption of heat and is indicated by a reduction in the rate at which the temperature rises if the heat is supplied at a uniform rate. The point at which the solution commences is known as the Ac. 1 point, and it can be determined in the laboratory by pyrometric measurements for any particular steel. In the hardening process, however, it is more important to know the point at which the solution is completed, and this is not well defined pyrometrically, being considerably affected by the rate of heating and also by the past history of the steel. Fortunately, however, the completion of the solution coincides with the disappearance of the magnetic properties of the steel, the point at which this occurs being known as the Ac. 2 point, and advantage can be taken of this fact in determining the exact moment for quenching in industrial hardening operations.

This principle is employed in the Wild-Barfield electric hardening furnaces which have recently been installed at the works of the Wilkinson Sword Company, Limited, Acton Green, W., for the heat-treatment of hollow-ground blades for safety razors. The installation has been carried out by Automatic and Electric Furnaces, Limited, 173–175, Farringdon Road, E.C. 1., and the essential parts of it are illustrated in Figs. 1 to 4 above. Fig. 1 is a view of the hardening furnace and accessories, while Fig. 2 is a longitudinal section of the furnace illustrating its design and construction. Fig. 3 is an electrically-heated air-tempering muffle, and Fig. 4 is a Mawdsley rotary converter for transforming the direct current supply of the works to the alternating current required for the furnaces. This machine is supplied with direct current at 220 volts and gives a single-phase output of 50 amperes at 165 volts and 50 cycles. The hardening furnace consists of a refractory tube, the section of which is similar to the shape of the door shown in Fig. 1; the tube is surrounded by a layer of insulating material and enclosed in a sheet aluminium cover with cast-iron ends. The refractory tube, which measures internally 11 in. wide, 4 in. high, and 17 in. from back to front, is heated by a nickel-chrome wire wound round the tube, the winding carrying 21 amperes when the furnace is working at its full capacity. The current, and consequently the temperature of the furnace, is regulated by the rheostat, mounted on the wall behind the furnace, as shown on the right of Fig. 1. A thermo-couple type pyrometer is provided for indicating the temperature of the furnace at all times.

In hardening small pieces, such as razor blades, the parts are packed in trays made of a nickel-chrome non-magnetic alloy, the complete charge containing about 200 blades weighing 7 lb. in the particular installation to which we are now referring. The charge is raised to the hardening temperature in about 30 minutes. The most interesting feature of the furnace is the means adopted for indicating that the material to be hardened has become completely non-magnetic and that the correct temperature for quenching has, therefore, been reached. For this purpose, a secondary

winding, having no direct connection with the heating winding, is provided round the casing of the furnace, as indicated by the dots in Fig. 2. This secondary winding is connected in series with the moving coil of an indicator enclosed in a rectangular box, shown in Fig. 1, and with a compensator which is a form of choking coil, having an adjustable iron core. Another winding on the compensator carries the main heating current, and by adjusting the position of the iron core when the furnace is empty, the electromotive force induced in the secondary winding on the furnace by the current in the heating winding can be exactly nullified. With the apparatus so adjusted, the insertion of a magnetic body into the furnace, by altering the induction between the heating and the secondary windings, will cause a current to flow in the latter, and this will deflect the needle of the indicator to the end of its scale. The needle will remain in the position of maximum deflection until the magnetic permeability of the steel in the furnace begins to diminish, when it will commence to move over the scale returning to the zero point when the steel has become completely non-magnetic. At this moment, the contents of the furnace are removed and dumped into a quenching tank without reference to the pyrometer reading.

It is, of course, the duty of the operator to see that the work does not remain in the furnace after the indicator needle has returned to the zero of the scale, this being the only precaution necessary to secure uniform hardening of the work. Once set, the compensator, which is shown in our illustration, Fig. 1, just above the rectangular box containing the indicator, requires practically no attention, but the operator can easily satisfy himself that its adjustment is correct by noting that the needle remains at the zero of the scale when the charge has been removed from the furnace. As previously mentioned, a pyrometer is provided to show the temperature of the furnace at any time, although it is not used to determine the hardening temperature; it is shown in Fig. 1 immediately below the magnetic indicator. To prevent overheating of the furnace, due to inattention on the part of the operator, an excess-temperature cut out is fitted. This consists of a loop of silver wire carrying the main heating current and located inside the furnace at the rear, as indicated on the right of Fig. 2. The gauge of the wire is selected so that it will carry the working current at the normal temperature of the furnace, but will be fused by the current if the temperature becomes too high. A red pilot lamp, shown at the top of Fig. 1, and connected across the safety fuse, lights up when the latter has melted, thus calling the operator's attention to the fact. The use of this device, we may add, has been found greatly to extend the life of the heating windings and the refractory materials of the furnace, both of which are, of course, liable to be damaged if carelessly allowed t become overheated. External fuses are provided, in addition, to protect the furnace from excess current due to a short circuit or any other cause.

After the blades have been hardened as described, they are collected from the quenching tank and again packed in trays. They are then placed in the air-tempering muffle, which is illustrated in Fig. 3. Two of the trays used are shown on the left of the illustration. The muffle is a rectangular chamber measuring 16½ in. by 6 in. by 23 in. internally, and heated by resistance windings which absorb about 2¼ k.w. It is not, of course, fitted with a magnetic indicator and can, therefore, be enclosed in a sheet steel casing. The tempering temperature, which is about 220 deg. C., is indicated by a mercury-glass thermometer, the stem of which projects above the furnace at the back, as shown in Fig. 3., and after having been maintained at this temperature for about 60 minutes the blades are removed for grinding and setting. The whole equipment illustrated is capable of heat-treating about 270 doz. blades in a working day of 8 hours, and the cost of current, at 1*d.* per kw. hour, amounts to about 2*s.* a day. The installation has now been in use for several months and we understand that the results obtained with it have been entirely satisfactory.

SOMERSET OIL SHALE.

UNDER the auspices of the Birmingham Branch of the Junior Institution of Petroleum Technologists a lecture was recently given at the University of Birmingham by Dr. W. Forbes Leslie, F.G.S., on the Somerset Oil Shale Fields. Many members of the Society of Chemical Industry (Birmingham and Midland Section) were present as well as members and students of the coal and oil mining, and engineering professions. A summary of Dr. Leslie's lecture follows.

Unlike most oil shales, those in Somerset when freshly broken gave a strong odour of paraffin. The sulphur content of the Somerset oil shales was about the same as that of the Scotch. Little or no pyrites was met with in the middle series of the shales, and the sulphur contained in the oil was principally in the form of thiophanes, and quite easily washed out. Dr. Forbes Leslie dealt with the treatment of the residue or ash of the shale after retorting, and said the nitrogen content which had been worked out principally in the middle shale series, was about 0·8 per cent., or a theoretical yield of 80 pounds per ton of sulphate of ammonia. On a commercial basis this would give about 50 lb. per ton. The amount of fixed carbon in the ash was about 20 to 25 per cent., or equivalent in a fuel value of one ton of coal in every five tons of oil shale ash.

When an oil shale was destructively distilled, oil, gas, and ammonia water were obtained. Oil shales, with the known exception of the Monterey shales of California, did not contain oil as such. Oil was obtained as a product of pyrolysis in the destructive distillation of the shale. The oil-producing substances of shale were considered to be asphaltic pyrobitumens, and on being treated they changed into a bitumen which was largely soluble in organic solvents, and after extraction from the shale became a semi-fluid or asphalt-like substance. Destructive distillation of oil shale was effected in closed chambers called retorts, and those classes of oil shales which were resistent to irregular and high temperatures were eminently suited for treatment by the Scotch vertical type of retort. Among such the Somerset oil shales were prominent —an oil 80 per cent. saturated being obtained by vertical retorts. On refining, such oil resisted cracking even at temperatures of 410 to 450 deg. C. This quality conferred an enhanced value on an oil because the quality was passed on to the various fractions into which a crude shale oil was split, and increased their market value and range of utility correspondingly.

The petrol in American shale oil was usually in large quantity up to and over 35 per cent. This was very high, even for the best Californian or Pennsylvanian petroleums, but it contained large percentages of unsaturated hydrocarbons, and in the refining treatment a large part of these were lost. A shale spirit would change in sunlight to a straw-coloured liquid, and even to a red ruby liquid, due to decomposition of unsaturated hydrocarbons. Gums and resins might be thus precipitated and would cause mechanical trouble in the motor-car. Consequently it was necessary to free the spirit from all decomposible unsaturates. Scotch oils contained smaller percentages of petrol than either American, Esthonian, or Kimmeridge oils, but the Scotch oil was more largely saturated than most of these. The Somerset shale oil contained 9·9 per cent. of petrol, and with the scrubber spirit this was increased to about 13·9 per cent. This spirit contained no unsaturates or only a small amount, and was "water white" on being refined, keeping its colour as well as the best petroleum petrols. The Somerset shale oils contained only 11·9 per cent. of kerosene, being the smallest percentage among the examples quoted. The gas oil fraction was 15 per cent. in Colorado shale oils, 30 per cent. in Scotch, and only 3·5 in Kimmeridge (Norfolk), Esthonian having 5·7 per cent., and Somerset 28·2 per cent. High percentages of gas oil were not considered an advantage in a shale oil or petroleum owing to the prices being so much less than for petrol, kerosene, or light lubricating oil. The 28·2 per cent. was too high in Somerset, and by careful refining it had been found possible to reduce this percentage to about 5·7 per cent., increasing the kerosene and light lubricating fractions correspondingly. Most gas oils were solid at ordinary temperatures, but Somerset gas oil was fluid and formed a high grade Diesel oil for naval use.

Of all fractions, however, in shale oil the most valuable were the light and heavy lubricating oils. The principal value in the Somerset shale oil was the large percentage of its lubricating fractions and the first grade quality possessed by them. It had 27·5 per cent. light lubricating oil and 18·7 per cent. heavy lubricating oil. The resistance of the shale to heat had been transmitted to its lubricating oils, so that no cracking of the heavy lubricating oil took place up to 410 deg. C. to 450 deg. C.—a remarkable and most valuable quality, especially when, in addition, it had the quality of "oiliness" and semi-fluidity at ordinary temperatures. It compared favourably with the best Russian lubricating oils, and its discovery in this country was likely to be of great commercial importance.

Somerset shale oil contained about 3 per cent. paraffin wax, and the "still coke" obtained from the ultimate distillation of the Kimmeridge (Norfolk) and Somerset shale oils was of fine quality suitable for varnishes. A combination of the residual shale ash with lias limestone gave a high quality Portland cement which set within seven hours. He would impress upon his hearers most of all that there was between Watchet and the Parrett one of the most important sources of cheap fuel, heat, and power in Europe. In addition to the oil, the cement, the nitrogen, the by-products, there were thousands of millions of tons of fuel available for development.

ARCA REGULATORS AT THE BRITISH EMPIRE EXHIBITION.

THE automatic regulation of pressure, temperature, humidity and other physical conditions of steam air, water and other liquids and gases plays such an important part in many modern industrial processes that the means available for carrying out such regulation under practical working conditions are of considerable interest to all engineers. Apparatus for this class of work has been illustrated and described in our columns on several occasions, an important example having been dealt with in our issue of February 9, 1923, on page 167, where we described, very fully, the products of British Arca Regulators, Ltd., Windsor House, Victoria-street, S.W. 1. It will be remembered that in the Arca regulators, an ingenious form of hydraulic relay, operated by the pressure, temperature or other physical condition it is desired to regulate, is employed to control the flow of water to a hydraulic cylinder, or other equivalent device, which may be used, for example, to regulate the opening of a valve in a steam pipe so as to control the pressure.

The principles of the system were explained in detail in the article above referred to, and some of its numerous applications were described and illustrated. These applications included the control of air temperature and humidity, steam pressure, voltage and current of electrical systems, position of electrodes in electric arc furnaces, supply of pulp to paper-making machines, and the pressure of the gas supply from producers. We now propose to deal with some more recent applications of the system and with some improved forms of the components lately introduced and shown by the firm on their stand in the Palace of Engineering at the British Empire Exhibition.

Figs. 1 and 2 opposite, illustrate a form of relay used for regulating the temperature of liquid contained in a tank or other vessel, the device being sufficiently sensitive to be affected by a temperature change of about ¼ deg. F. One of the applications of this relay is in connection with the heating of volatile liquids, which must not exceed a certain maximum temperature, but which it is desired to keep as close to the maximum permissible temperature as possible. The relay comprises a thermostat immersed in the liquid and consisting of a metal tube closed at one end and containing a rod of special steel having a very low co-efficient of expansion. The rod, which is fixed to the distant closed end of the tube, as shown in Fig. 2, extends through the wall of the containing vessel and also through the box containing the relay which is mounted on the side of the vessel. Near the free end of the rod is fitted a sleeve formed with a knife edge, which engages with a groove in the short arm of a lever. The latter is pivoted on to the back plate of the relay and held in position by a spring, as shown in Fig. 2, so that the longitudinal movement of the rod, which results from the expansion or contraction of the external tube of the thermostat following any change in temperature of the liquid in the containing vessel, will cause the lever to tilt. The free end of the lever, as shown in Fig. 2, is situated close to a nozzle through which a jet of water issues when the apparatus is in use, the water running to waste through a pipe connection at the bottom of the relay box, also to be seen in the illustration referred to. The movement of the lever towards or away from the nozzle causes the water pressure in the pipe supplying the jet to rise or fall, and the pressure variations are employed to operate a valve controlling the supply of the heating steam to the liquid in the tank. The temperature of the liquid is regulated by adjusting the position of the knife-edge, above referred to, by means of a pair of milled-edge lock nuts clearly shown in Fig. 2. The cover, which protects the moving parts and also serves to collect the water issuing from the jet, has been removed in Fig. 1 in order to show the working parts. It is normally held in position by nuts on the two studs shown in that illustration.

A form of regulating valve for steam which is suitable for use with the thermo-relay described above or with any other type of relay functioning on the Arca hydraulic principle, is illustrated in section in Fig. 3. It is known as the "Compact" valve, and is used in place of the hydraulic cylinder, described in our previous article, when the movement of the valve required to give the necessary degree of regulation is comparatively slight. The valve, as shown in Fig. 3, is of the single-seated balanced type, and the valve spindle is connected at its upper end to a flexible diaphragm enclosed in a gun-metal casing. The water supply to the relay is passed through the space above the flexible diaphragm, so that when the pressure rises due to the partial closing of the jet, the valve spindle is forced downwards against the action of a spring, thus opening the valve and increasing the supply of steam. When the hydraulic pressure above the diaphragm falls, owing to the movement of the relay lever away from the nozzle, the valve is moved upwards by the spring to

ARCA REGULATORS AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. BELLISS AND MORCOM, LIMITED, ENGINEERS, BIRMINGHAM.

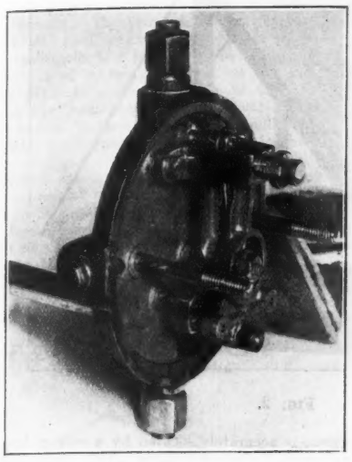
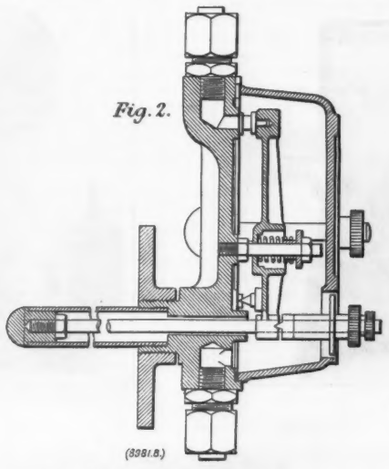


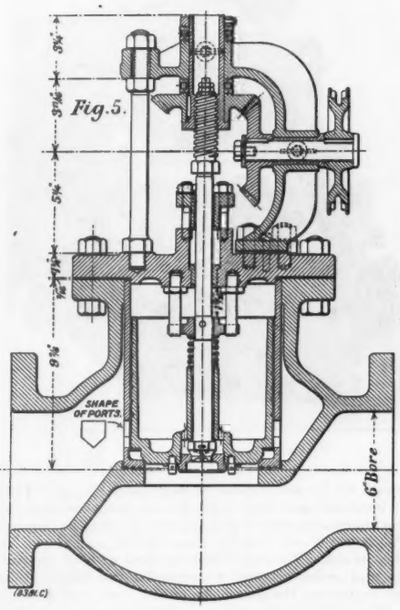
FIG. 1.

FIG. 4.

reduce the supply of steam. Under steady conditions, the valve, of course, takes up an intermediate position, in which just sufficient steam is supplied to maintain constant conditions in the plant being regulated. Fig. 4 is a photographic illustration of one of these valves having a relay mounted on the body, and thus forming a complete regulating unit. The valves, we may mention, are made for use on pipes of from ½ in. to 2½ in. bore and a special feature of their design, which will be evident from Fig. 3, is that the bodies are reversible, so that the downward movement of the spindle can be used either to open or to close the valve, as required.

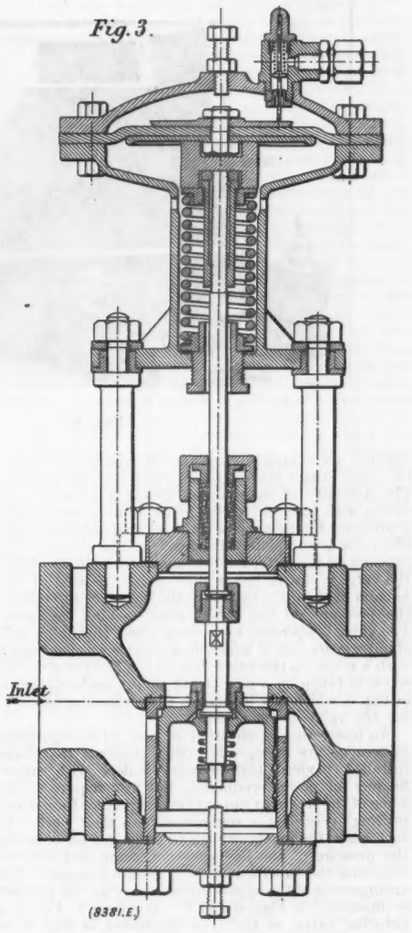
Another important point in connection with these valves is that they can be used to effect a form of dual control in cases where it is desired to regulate, for example, both the pressure of the steam supplied and the temperature of a liquid being heated. In such cases, the space above the diaphragm is connected to two relays, one controlled by steam pressure and the other by liquid temperature, so that the movement of either of the relay levers relatively to the jets will affect the pressure of the water acting on the diaphragm, as

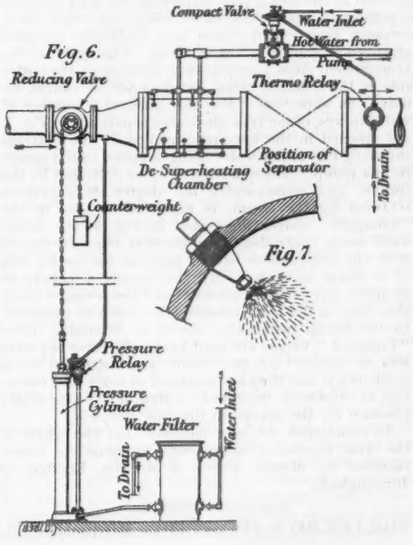




explained above. This arrangement has been used for milk Pasteurisers, in which it is essential for the milk to be maintained at a constant temperature, and also necessary to prevent the pressure of the steam supplied to the heating coils from exceeding about 2 lb. per square inch, in order to avoid the possibility of burning the milk in actual contact with the coils.

A recent design of steam-pressure reducing valve operated by a chain and counterweight from a long-stroke hydraulic cylinder, is illustrated, in section, in Fig. 5. The pressure relay and the pilot valve, which control the inlet and outlet of water to the hydraulic cylinder, have been illustrated and described in the previous article, above referred to, so that we now propose to deal only with the valve itself. This, as shown in Fig. 5, is of the single-seated balanced type, and it has been designed to secure steam tightness with accurate regulation at small openings, and also to avoid the cutting of the seat usually experienced under these conditions with highly superheated steam. As will be seen from the illustration, the valve proper is in the form of a piston working in a liner fitted in the body and having a seating formed on an internal flange at its lower end. When the valve is open, steam from the inlet end of the body passes through ports in the side of the liner and thence to the outlet, the quantity passing depending upon the extent to which the ports are uncovered by the balancing piston. The shape of the ports is indicated on the left of the illustration, from which it will be seen that the lower edges are notched shaped, so that a longer travel is required at small openings than at large openings to effect a given





reduction, or increase, in the quantity of steam passing. A finer regulation of the flow is thus obtainable than would be possible with plain rectangular ports. Moreover, since the area of the annular passage between the main valve and its seating is always larger than the combined uncovered areas of the ports, the velocity of steam over the seating is comparatively low, thus eliminating the cutting action that would otherwise be experienced at small openings. The ports, it should be

PROJECTION MICROMETER FOR MEASURING FINE WIRES; EMPIRE EXHIBITION.

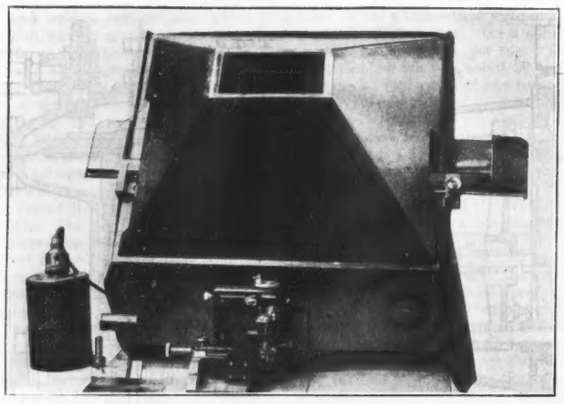


FIG. 1.

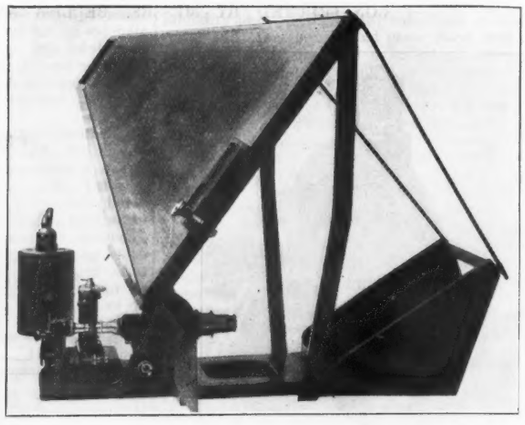


FIG. 2.

noticed, are completely covered by the piston before the valve comes into actual contact with the seating. The difficulty of maintaining steam tightness which occurs with balanced valves of the double-seated type is obviated by the use of a single seating only, although the valve is completely balanced by the piston. The pressure on the latter tends to maintain tightness when the valve is closed, but a pilot valve, located at the bottom of the main valve spindle, is provided to release the pressure on the piston when opening the valve. The valve is operated by a chain-wheel through a pair of mitre gears, one of which incorporates a nut engaging with a screw on the valve spindle. The thrust of the screw is taken on a pair of ball thrust washers, shown in Fig. 5, which also illustrates the method of connecting the valve to the spindle.

An interesting application of the Arca regulating system occurs in manufacturing concerns that have installed modern high-pressure boilers with superheaters for power production, but also require to use some of the steam to run existing engines or for various heating operations in connection with their work. In such cases, the regulators can be employed for reducing the pressure of the high-pressure steam and also for removing the superheat to any required extent. The arrangement of the apparatus necessary for the purpose is illustrated in Figs. 6 and 7. As shown in Fig. 6, a reducing valve, of the type illustrated in Fig. 5, is inserted in the steam pipe conveying the high-pressure superheated steam, the valve being controlled by a pressure relay, pilot valve and hydraulic cylinder arranged as shown in the drawing. This part of the arrangement gives a constant low-pressure on the outlet side of the reducing valve, but does not, of course, remove the superheat. For this purpose a number of water sprays, of the type illustrated separately in Fig. 7, are inserted in the low-pressure pipe in the positions shown in Fig. 6, hot water being supplied to the sprays from a pump. The quantity of water delivered by the sprays, and consequently the degree of superheat retained by the steam, is regulated by one of the "Compact" valves illustrated in Fig. 3, the valve, itself being controlled by a thermal relay connected with the low-pressure steam pipe on the outlet side of a steam separator. By this means a supply of steam at any required pressure and temperature lower than that in the high-pressure boilers can be obtained. In the actual installation shown at Wembley, three "Compact" valves are used to supply three separate sets of sprays. All the valves are controlled by a single relay, and they are arranged to come into operation in succession, in order to maintain sufficient water pressure for the sprays to function properly.

In conclusion, we may mention that the whole of the Arca regulating valves and apparatus are manufactured by Messrs. Belliss & Morcom, Limited, of Birmingham.

THE LEWBECK PROJECTION MICROMETER.

IT will be obvious to anyone who has examined the magnificent display of engineering material collected at the British Empire Exhibition that the exhibits include innumerable products such as belts, packing, lubricants, &c., of considerable importance to the industry which do not lend themselves to illustration, and of which a mere description would be particularly tedious. Wires and cables must be included among the type of product to which we are referring, and for this

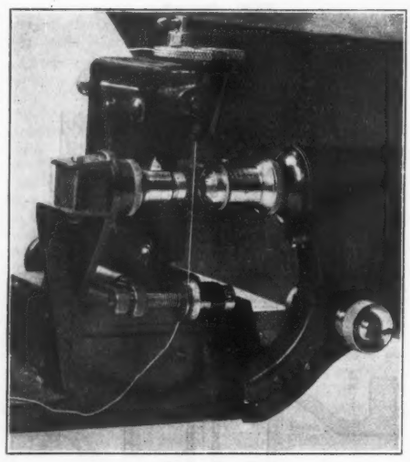


FIG. 3.

reason we do not propose to describe the great variety of insulated and bare wires for all purposes made by the London Electric Wire Company and Smiths Limited, Playhouse Yard, Golden Lane, E.C.1, and shown on their stand. We may, however, deal with an interesting and useful instrument included in this firm's exhibit for measuring the diameters of fine wires and fibres.

The instrument, which is illustrated in Figs. 1, 2 and 3 above, is known as the Lewbeck projection micrometer, and it operates by forming a highly magnified image of the wire or fibre on a translucent screen, which is provided with an adjustable transparent scale for measuring the width of the image formed. The essential parts of the instrument, which includes an illuminating lamp, projection microscope, and reflecting mirror, in addition to the translucent screen, are all mounted in fixed positions on a rigid baseplate, and the only adjustment necessary in making a measurement is that required to bring the zero of the scale into coincidence with one side of the magnified image on the screen; the position of the other side of the image on the scale then gives the diameter. The scale, we may mention, is divided in tenths of an inch, and as the magnification of the image is 1,000 diameters, each division of the scale corresponds to 0·0001 in. It is, however, quite easy to estimate to one-fifth of a scale division, and consequently readings can be obtained to within about 0·00002 in.

The source of light is a Pointolite lamp enclosed in a lantern shown on the left of Fig. 1. Light from the lamp passes through an aperture in the side of the lantern and travels by way of a lens and reflecting prism to the condenser of the microscope. Between the condenser and the microscope objective, which is of the Beck apochromatic type, the wire is secured in a holder, the arrangement of which can be seen in Fig. 3, which illustrates this part of the instrument to a larger scale. The wire is clamped at its upper end and held in a spring clip at the lower end, while the central portion of the wire, between the condenser and objective, is accurately located by a pair of brackets formed with V-shaped grooves. This device renders unnecessary any movement of the wire for focussing, but the holder can be moved laterally, by means of a micrometer screw shown in Fig. 1, to bring the wire into the centre of the field or to adjust the position of the image on the screen relatively to the scale without moving the latter. It is also possible to rotate the wire through an angle of 90 degrees about its axis, so that two diameters at right angles can be measured in succession.

The image formed by the miscroscope objective, and further magnified by the compensating eyepiece, is reflected on to the screen by a mirror located at the back of the apparatus, as shown in Fig. 2, extraneous light being excluded from the back of the screen by curtains not shown in the illustration. The front of the screen is covered by a pyramid-shaped view box having a rectangular opening at the apex through which the observer can see the image of the wire clearly without darkening the room in which the apparatus is located. The adjustable scale, the ends of which can be seen protruding through the sides of the view box in Fig. 1, lies flat on the screen in order to avoid parallax, and it can be moved in the direction of its length by rack and pinion gear operated by the knurled knob on the right-hand side. The whole operation of inserting a wire and measuring its diameter can thus be carried out by an operator seated or standing in front of the instrument without changing his position, and consequently accurate measurements can be made rapidly and easily.

By changing the objective of the microscope, the magnifying power can be reduced to 100 diameters for measuring wires of larger gauge, each scale reading then, of course, corresponding to 0·001 in. For calibrating the instrument from time to time, the wire holder is arranged so that a glass slide with parallel lines accurately ruled at a definite distance apart can be inserted in the focal plane of the objective, and the image of the lines projected on to the screen can be used to check the scale readings in a manner which will be obvious. It is, perhaps, hardly necessary to point out, in conclusion, that in comparison with measuring instruments of the type in which two jaws are brought into contact with the opposite sides of a wire, or other similar body, the optical-projection method has the advantage that the measurements are not affected by the presence of dirt on the anvils or by the compression of the material by the contact pressure; the latter is, of course, of particular importance in the measurement of comparatively soft fibres. Another point in favour of the optical projection method of measurement is that the accuracy of the results obtained is not impaired by the wear of the apparatus.

SAFETY-LAMPS GIVING WARNING OF GAS.*

By Professor W. M. THORNTON, D.Sc., D.Eng.

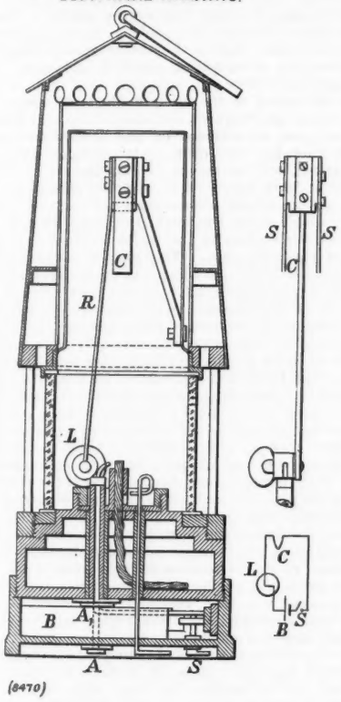
WHEN air containing combustible gas, such as fire-damp or petrol-vapour, is brought into contact with the flame of an oil lamp, the gas burns around it as a pale blue secondary flame. This cannot be observed unless the bright flame is lowered almost to vanishing-point, but the envelope of incandescent gas is always present, and its heat of combustion is added to that

* Paper read before the Institution of Mining Engineers, at Newcastle, on April 26, 1924.

of the oil flame. The lamps about to be described were designed to utilise this additional heat in the air ascending from the flame so as to give indication and warning of the presence of gas. There are devices, such as the Philip-and-Steele detector, in which the heat of combustion on the surface of hot wires raises their resistance and gives a measure of the proportion of gas present. The principle of the present lamps is to make the heat actuate moving parts whose motion either measures the gas or gives a warning. The problem is of growing interest on account of the necessity for accurate knowledge of the presence of gas in the neighbourhood of electrical machines such as coal cutters, where a small blow may suddenly occur, and it is always present in fiery mines.

The first solution obtained was by making an oil lamp actuate an electrical battery contact, which rang a bell or lit a warning signal lamp when gas appeared. Two forms were devised: the first (shown in Fig. 1) is self-contained and portable. It has a hollow base fitted to the existing oil chamber, with a small dry battery B and a switch, worked like the pricker, from the bottom of the lamp. In series with the

Fig.1. OIL-LAMP WITH ELECTRICAL WARNING.



(6470)

Fig.2. INDICATING OR DEPUTY'S LAMP: SINGLE-STRIP TYPE.

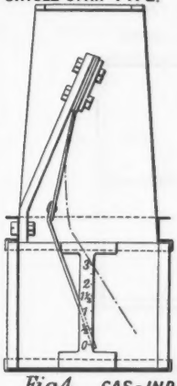


Fig.3. EXTINGUISHER TYPE OF SAFETY LAMP.

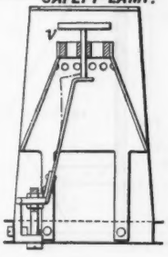
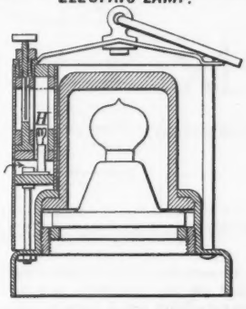


Fig.4. GAS-INDICATING ELECTRIC LAMP.



battery is a small electric lamp L such as is used in a pocket flash-lamp, but with a red glass. From it a wire is led to the electrical contact C fixed to the inner gauze. The moving parts consist of two bi-metallic strips S screwed to a block of heat-resisting insulating material. These bend under the influence if the heat rising from the flame, and are so adjusted that they do not touch under any normal conditions of burning, even with the wick rather higher than usual. When gas is present in the air around the lamp, the added heat from the "cap" and from the "spiring" flame causes the strips to bend together and make contact, establishing an electric circuit through the battery and warning lamp and giving a red light which is sufficiently distinctive to attract the attention of the miner. In this form of lamp the contact A, by which when a lamp has gone out it is electrically relit below ground, is utilised as one of the electric leads to the red lamp, the side contact of which rests against it, while the end contact is led to the strips by the rod R. By attaching a wire to this bottom contact and introducing an external battery and bell, a warning both acoustic and visual can be made simultaneously. This latter form has the advantage that the red lamp blinks rapidly as the bell makes and breaks contact, and thus calls instant attention to the warning light. It is, of course, possible to carry the leads from the lamp to the shaft landing or to bank, and so give warning in the manager's office of a dangerous accumulation of gas at any desired point in the pit; and though such an extension of the idea would rarely be desired, it is well to point out that it can be effected. The second form of lamp omits the red light and the battery in the base and the base itself, and is intended solely for the purpose of giving warning by an electric signal bell or red light, or other form of indicator. The oil lamp contains only the electrical contact by which the circuit is closed. The external battery and bell are connected in circuit with the contact A_1 and the metal frame of the lamp.

Another form of this arrangement is to make the contact open instead of closed and so *extinguish*, in the neighbourhood, an auxiliary electric lamp, which might be of the portable electrical pattern; but this is rather a roundabout way of giving a warning that can be more simply and directly effected by the oil-lamp alone.

This type of lamp with contacts above the flame can be made to work readily with 1 per cent. of methane in air or with ½ per cent. of petrol-vapour, and to give its reading within a minute. The following actual readings obtained show how closely the rate of movement of the strips depends upon the amount of heat added by the gas. The time given is that from the moment of switching on the gas to that of the warning signal:—

Percentage of gas.	Time, in seconds.	Product.
1·0	60·0	60·0
2·0	30·5	61·0
3·0	19·5	58·5
4·0	15·0	60·0

The greater percentage of gas from a blow, the more rapidly the warning is given. The figures show that the device is accurate within the limits of observation in mixtures likely to be met with in practice.

The second solution was to obtain a lamp which shows by a pointer on a scale the proportion of firedamp present, without the necessity of lowering the flame. One of the great disadvantages of testing for gas by observing the cap is the risk of losing the light; another is that where it is necessary to test for gas in places where work is going on, all lights in the neighbourhood are shaded and the work is stopped. With the form shown in Fig. 2 the flame is kept full on, and the proportion of gas is read by the movement of a pointer across the scale. This pointer is attached to the end of a bimetallic strip supported from the lower part of the inner gauze, and moves across the lamp as the strip bends. The scale in one form consists of an I-shaped piece of brass which slides around the glass in the grooves of the holders. The vertical part is graduated by calibration in a standard gas-tester, and the reading is taken by observing where the pointer crosses the scale. The time taken to obtain a reading of the gas-percentage is about the same as that when observing the "cap." By using two strips which bend together so that their pointers cross, no greater sensitiveness, but what may be called double certainty, is obtained. The disadvantage is that the adjusting-screw rod by which the zero position is set at the bottom of the scale comes in front of the crossing point and makes the reading rather more difficult.

An emphatic warning of the presence of gas is given by total loss of light. This occurs usually in mixtures of 7 per cent. and upwards, and is caused in an ordinary safety-lamp by the thin blue flame of the cap extending into and filling the gauze in such a manner that fresh air cannot enter to feed the oil flame. Since men have to be withdrawn at 2½ per cent. of gas and electricity cut off at 1¼, a contrivance that will give rapid warning of gas of these percentages might prove a life-saving device, although it is possible to continue to work in much more highly inflammable mixtures. The method used to extinguish an oil-burning lamp when 2½ per cent. of gas occurs is to have a bimetallic strip moving so as to release a drop-valve V, which closes the outlet passage and prevents air-circulation through the lamp (Fig. 3). The valve closes the top of a conical chimney fixed inside the inner gauze, and before gas appears is held open by its spindle resting on the top of the moving strip bent over horizontally. The extra movement induced by the presence of gas allows the spindle to drop clear of the support, and the valve then closes. All that is desired is to call attention to the presence of gas, not necessarily to lose the light. There is, therefore, a by-pass consisting of a few holes in the side of the cone which allow sufficient air to circulate to give a much reduced light by which the worker can travel out. This device can be made to operate with 1 per cent. of gas, but is normally set for 2½.

A miner's electric lamp which will indicate gas had, has, up to the present, not been produced. The problem has two parts—(1) to find a lamp which can be used as the oil-lamp now is, i.e., by lowering the light and examining for gas, and (2) to obtain one to act as does the extinguisher type by giving warning while the lamp is on full light. There would be little difficulty in solving either of these problems if the power which can be obtained from the battery of a portable electric lamp were not so small, usually about 2 watts, which rules out the use of a lamp and heater in series. When these are in parallel, the battery will not hold its voltage for the shift, and it is not practicable to increase the weight. The demand for an electric lamp to satisfy the second condition is not so urgent as that for the first. Such warning electric lamps can be made to work readily enough on a system of lighting recently suggested,* in which double-filament lamps are used, for low voltage when being carried about and for high voltage (15 to 25) when operated from the power-mains. The power is in the latter case not restricted, and a lamp can then give up to 25 candle-power and simultaneously give another warning by switching off the light to the lower voltage if gas appears.

A convenient way of making a single-filament miner's lamp indicate gas is shown in Fig. 4. One of the supports of the protective hood is removed, and a tube containing an electric heater and moving indicator is substituted for it, these being rigidly attached both to the hood and to the frame of the lamp so as to retain the same mechanical strength. The contact-plate by which the battery is connected to the lamp is modified so that in an intermediate position the lamp is cut out of circuit and the heater taking the same current thrown in. The heater in one form is attached to a bimetallic strip, which moves and makes contact with a screw-adjusted point, closing the lamp-circuit and giving positive indication of the presence of gas by the lighting of the lamp. Instead of the bimetallic strip, a very sensitive arrangement is obtained by the combination of an air-thermometer with mercury contact movement, as shown in the illustration. This reads to 2½ per cent. in a few seconds. The same arrangement can be made to give warning by breaking the lamp-circuit when the lamp and heater are running in parallel, or by switching over from one to the other, thus putting the lamp in and out. The former, as previously stated, makes too heavy a demand upon the battery. The chief difficulty in making electric lamps to indicate gas is to get a current of air to pass over the heater at the proper rate. If it is too slow, the extra heating effect of the gas is too small to be observed; if too fast, the heater is cooled by the air-current more than it is heated by the gas present. With only 2 watts available, the electric heat is not sufficient to maintain the desired air-current by thermal action alone and to detect gas unless a very sensitive indicator is used. Some form of small pump or blower, such as that in a scent-spray, greatly accelerates the rate of detection, but the delivery must be through a needle-valve in order that the rate of flow may be steadied.

* See paper on "Some Researches on the Safe Use of Electricity in Coal Mines" Read by Professor W. M. Thornton before the Institution of Electrical Engineers, on January 31, 1924, also ENGINEERING "The Safety of Electricity in Mines," page 179, current volume.

THE EFFECT OF LENGTH ON THE SKIN FRICTION OF FLAT SURFACES.*

By Dr. T. E. STANTON, F.R.S. and Miss DOROTHY MARSHALL.

THE experiments described in the present paper were undertaken, not for the purpose of increasing the amount of data available for the prediction of the skin friction of ships, but to throw light, if possible, on certain characteristics of the distribution of friction over plane surfaces which are still obscure. The particular feature which is here discussed is the variation in frictional resistance of a rectangular plate whose length is great compared with its width, as the length is increased.

As is well known, the results of all the experiments on long plates in air or water, from those of Mr. William Froude in 1872 to those at the National Physical Laboratory in 1915, agree in indicating a gradual falling off in frictional resistance as the length of the plate is increased. This characteristic is very well shown in Plate I of Mr. G. S. Baker's paper on Model Experiments.† To take an example from Mr. Froude's experiments, the resistance of the last foot of a plate 28 ft. in length was found to be 87 per cent. of the mean resistance of the whole plate. It has been commonly assumed that this declension of resistance is directly connected with the velocity of the frictional wake set up by the plate, and that the frictional resistance instead of being proportional to the square of the relative velocity of the plate and the undisturbed water, is really dependent on the relative velocity of the plate and the water in its immediate vicinity. Thus, taking Calvert's determinations of the velocity of frictional wake for a 28-ft. plank,‡ this latter speed, 28 ft. from the leading edge, was found to be only half that at the leading edge, and therefore according to the assumption above the resistance of the last foot should be only one-quarter of that of the first foot, which is very much less than what is actually observed.

It was this discrepancy between the observed friction, and that which would be expected from the amount of the frictional wake, which led Mr. Froude to draw attention to the matter in an Appendix to his report. From the consideration that "it is the motion of the surface relative to contiguous particles and not relative to distant ones, that governs the resistance," he remarks that "instead of finding it difficult to explain why the resistance per square foot grows less as the length is increased, the perplexing question is how the rate of declension is so slow." As an extreme case, he considers the last foot of a plate 500 ft. in length, which enveloped in a favouring current having for a breadth of many inches scarcely less speed than the surface itself would be experiencing the same resistance as when entering undisturbed water. The explanation of the phenomenon which Mr. Froude suggests is that "the current is greatly disturbed by eddies, and these no doubt furnish a machinery by which the distribution of velocity is modified—the modification being of such sort that relatively undisturbed particles are being perpetually *fed* inwards towards the surface from the outer margin of the current, and it is by this agency alone that the resistance throughout the length of the surface is so little reduced as those experiments prove."

It may be remarked that Mr. Froude's views do not appear to have been universally accepted, and that the frictional wake theory mentioned above still has supporters, in spite of the general agreement between the results of experiments as to the comparatively slow declension of friction with length. For example, in a paper§ on "Turbulent Motion and Skin Friction" read before the Institution four years ago, Professor Havelock develops a formula for the resistance of a plane surface in the form

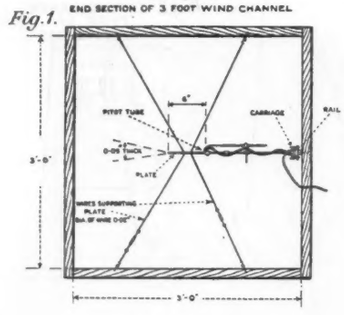
$$R = 0{\cdot}004\, v^2$$

where v is the velocity of apparent slip at the surface, or the velocity of the turbulent motion relative to the surface and in its immediate vicinity. In deriving this formula, it is admitted that the skin friction will be proportional to the first power of the velocity at a given distance from the surface in the extremely thin layer of fluid which is in contact with the surface and in laminar motion; but it is claimed that this layer is so thin (of the order of one-hundredth of an inch) that ordinary estimations of the speed at the surface can only measure the velocity of the turbulent motion immediately outside this layer, and, further, that the friction can be taken to be proportional to the square of this relative velocity.

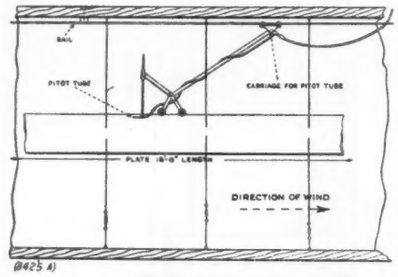
One objection to this treatment is that the change from turbulent motion to laminar motion is not so abrupt as is here supposed. It has been shown by the authors* that the transition from turbulent to laminar flow takes place so extremely gradually that no precise value can be assiged to the distance from the surface at which turbulent motion is fully established. It is clear, therefore, that different investigators are likely to differ in their estimations of this relative velocity of turbulent flow for the same conditions. Thus, when applied to Mr. Calvert's results, obtained by fixing a Pitot tube, $\frac{1}{8}$ in. in diameter, to the surface of the plank, and calculating the relative velocity from the measurements of the dynamic head in this tube at different distances from the leading edge, the formula gave results in agreement with the known resistance; but it is probable that considerable discrepancies would have been found if the Pitot tube had been appreciably larger or smaller in diameter than was actually the case. Apart from these considerations, however, there is, in the authors' opinion, very good evidence for dissenting from the view that skin friction can be expressed in terms of the relative velocity of surface and fluid discussed above; and it is thought that, in view of the importance of the subject to naval architects, an account of this evidence may be of interest to the Institution, more especially,

SURFACE FRICTION OF 16 FOOT x 0·5 FOOT PLATE IN AIR
SCALE ⅛ FULL SIZE
END SECTION OF 3 FOOT WIND CHANNEL

Fig. 1.



SECTIONAL PLAN



perhaps, for the reason that the method which they have used is based on the principle, laid down by Mr. Froude in the note from which the above extracts have been quoted, that when a surface moves through a fluid the friction exerted on the surface must be exactly equal to the momentum gained by the fluid.

The possibility of applying this method in practice depends, of course, on whether an instrument can be devised which will measure with sufficient accuracy for the purpose the changes in momentum, produced by the motion of a surface through a fluid, which are necessary for the calculation of the skin friction. The use of a Pitot tube at once suggests itself, since it is well known that the distribution of velocity in a fluid in turbulent motion can be determined with considerable accuracy from the measurement of the dynamic head produced in the tube when facing the direction of flow. There is, further, the advantage that the changes in momentum which take the form of changes in the static pressure of the fluid are also capable of measurement in the same tube. The validity of the use of the Pitot tube for friction determinations must, however, depend on the extent of the agreement of the results obtained with those from other methods of known accuracy, since it appears probable that in cases in which the eddies produce in the fluid are large compared with the diameter of the Pitot tube, its use would not be valid. General experience in recent years indicates, however, that the disturbances set up by pure skin friction are on a sufficiently small scale for the method to be used with some hope of success.

A simple illustration of the method may be obtained from the data given in Mr. Calvert's paper,* in which the variations in the relative velocity of surface and water, in a plane normal to the plank through its centre line, were determined by means of a Pitot tube, and are plotted in Fig. 9 of his paper. Neglecting the momentum transformed into pressure, and assuming the curve to apply to planes normal to the surface near the edges as well as that through the centre line, the gain of molar momentum by the fluid at a distance of 28 ft. from the leading edge will be found to be roughly 3 lb. per foot width at 400 ft. per minute, which is some 20 per cent. less than Mr. Froude's experimentally determined value for a 28-ft. plank.

Similar determinations of the surface friction of flat surfaces in currents of air have also been made at the Royal Aircraft Establishment and at the National Physical Laboratory, and reasonable agreement with the results of other methods has been found. In all cases hitherto studied, however, the assumption has been made that the surface is of infinite extent at right angles to the direction of flow, *i.e.*, that the flow is two-dimensional, so that it is only necessary to measure the changes in momentum in one plane parallel to the flow and normal to the surface. It is clear, however, that in the case of long, narrow planks this condition is not approximately fulfilled, and therefore the effect of the long edges may be considerable. In order to use the method for such long narrow planks it would be necessary to treat the problem as one of three dimensions, and to explore the whole region surrounding the plank, an investigation which is obviously of a very laborious nature.

The difficulties of the other methods of measuring skin friction are, however, so considerable that during the last year an attempt on the three-dimensional investigation has been made at the National Physical Laboratory, and the results of experiments on a flat steel plate 16 ft. long by 6 in. wide are here given.

The nature of the observations will be clear from Fig. 1, which shows the method of suspension of the plate for exploration of the region in the neighbourhood of the long edges. This method of suspension by thin wires is the one which was developed after the trial of several others, all of which were rejected on account of interference with the air flow. For measurements in the normal plane through the centre line, the plate was suspended vertically by a similar system of wires passing through holes near the long edges. The Pitot tube was carried by a light bracket attached to a travelling carriage moving on rails fixed to the side of the channel and actuated from outside. The method of making the observations was to set up the Pitot tube at a fixed distance from the surface and take a series of observations of the pressure at every foot interval, commencing from the leading edge of the plate, to the back edge. On the completion of this series another setting of the Pitot tube was made in the same plane normal to the surface, and this was continued at gradually increasing distances from the plane of the surface until the region of the air stream which was unaffected by the plate was reached. This process was then repeated in another normal plane and continued until the region unaffected by the long edge was attained.

The observations in three of these planes, (1) through the centre line of the plate, (2) through the long edge, and (3) 1·6 in. outside the long edge, are shown plotted in Figs. 2, 3 and 4. The contribution to the total friction, of any strip of the disturbed air current of unit width parallel to the centre lines of the plate and of any desired length, could then be evaluated in the following manner. Taking the observations for any one of the normal planes the values of the momentum at the required distance from the leading edge were scaled off and plotted on a base of distance from the surface. The area between the resulting curve and the lines of zero momentum and distance from the surface was then evaluated by a planimeter and tabulated. This process was repeated for all sections of the plate and for all the normal planes of observation. Points were then plotted having ordinates proportional to those areas, and as abscissæ the distances of the observation planes from the plane through the centre line of the plate, as shown in Fig. 5. If the scale of the ordinates be taken as the friction in lb. per unit width of strip considered, and the abscissæ in feet it will be clear that curves drawn through the extremities of the ordinates enclose areas between the two axes which represent the total friction of the surface considered. These areas have been evaluated by a planimeter, and the values of the total friction are given in the column on the right of Fig. 5, and for convenience of reference are also plotted in Fig. 6 from which it will be apparent that over this particular range in speed-scale the effect of length is small.

From an examination of the curves in Fig. 5 it will

* Paper read at the Spring Meetings of the Sixty-fifth Session of the Institution of Naval Architects, April 11, 1924.

† "Proceedings of the North-East Coast Institution of Engineers and Shipbuilders," November, 1915.

‡ Trans. I.N.A., 1893.

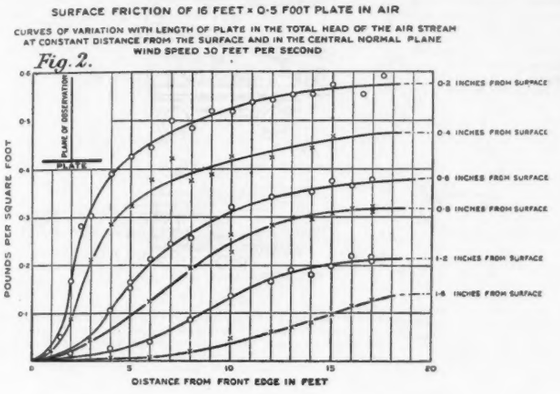
§ Trans., I.N.A., 1920.

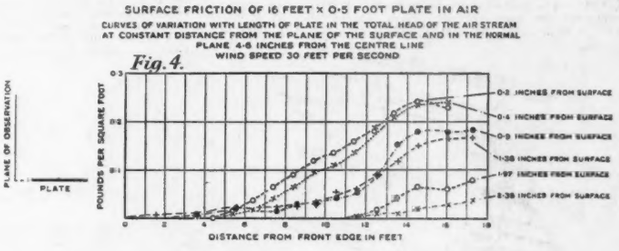
* "Proceedings of Royal Society," A, vol. xcvii, 1920.

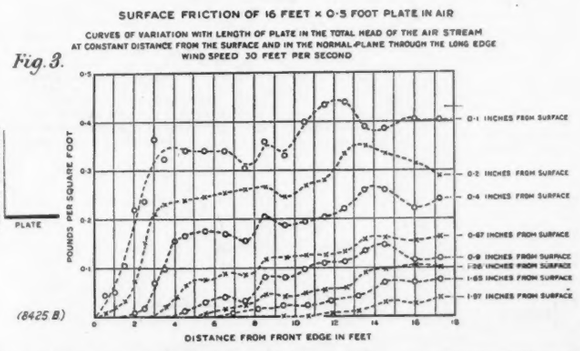
* Trans. I.N.A., 1893.

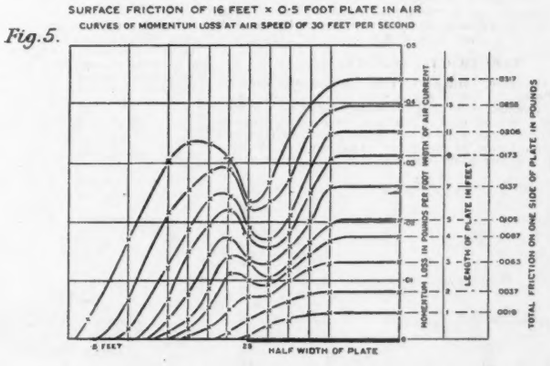
be seen that the departure from a state of two-dimensional flow is very marked, the region affected by the long edge of the plate at a distance of 16 ft. from the leading edge amounting to 50 per cent. of the width of the plate on either side. This brings out clearly the fact that in experiments on long plates the effect of width, so far from being negligible as has been commonly supposed, is of considerable importance, for obviously any strict comparison of the resistances of plates on a basis of length alone is invalid, *i.e.*, entire geometrical similarity is essential. An interesting feature of the curves is the marked inflection in the region above the long edge of the plate. It was at first thought that this peculiarity was due to the interference of the suspending wires, but an examination of the observations showed that the effect was due to a reduction in the velocity slope due to the effect of the broad edges in Zahm's experiments. These were 1 in. wide, and would be subject to a higher intensity of skin friction than the sides, and if this factor were taken into account the agreement would be closer than that shown above.

Effect of the Velocity of Frictional Wake.—One of the most interesting results of the experiments with the 16-ft. plate is the light thrown on the supposed effect of the intensity of the frictional wake discussed in the early part of the paper. For the purpose of the determination of the velocity of the frictional wake a small Pitot tube was placed with its centre at a distance of approximately $\frac{1}{16}$ in. from the surface, as in Mr. Calvert's experiments, and 15 ft. from the leading edge. At a wind speed of 30 ft. per sec. the speed at the Pitot tube was 18 ft. per sec., corresponding with a frictional wake of 12 ft. per sec. Assuming the friction laminar flow.* As mentioned above, the total thickness of this layer is of the order of one-hundredth of an inch, so that the experiment is one of considerable difficulty; but as the appliances were available an attempt was made. Briefly described, the apparatus consists of a rectangular Pitot tube fitted into the surface on which the friction is to be measured, the side of the tube adjacent to the surface being supplied by the surface itself. This was fitted to the 16-ft. plate at a distance of 15 ft. from the leading edge, and 1·2 in. from the long edge. On making a test at a wind speed of 30 ft. per sec., it was found that the Pitot tube readings were too small to be reliable, and, consequently, the wind speed was put up to 50 ft. per sec. The observations obtained are plotted in Fig. 7, from which it will be seen that the velocity slope at the boundary was $3{\cdot}45 \times 10^4$ sec. Taking


SURFACE FRICTION OF 16 FEET × 0·5 FOOT PLATE IN AIR
CURVES OF VARIATION WITH LENGTH OF PLATE IN THE TOTAL HEAD OF THE AIR STREAM AT CONSTANT DISTANCE FROM THE SURFACE AND IN THE CENTRAL NORMAL PLANE
WIND SPEED 30 FEET PER SECOND
Fig. 2.
POUNDS PER SQUARE FOOT
PLANE OF OBSERVATION
PLATE
0·2 INCHES FROM SURFACE
0·4 INCHES FROM SURFACE
0·6 INCHES FROM SURFACE
0·8 INCHES FROM SURFACE
1·2 INCHES FROM SURFACE
1·6 INCHES FROM SURFACE
DISTANCE FROM FRONT EDGE IN FEET


SURFACE FRICTION OF 16 FEET × 0·5 FOOT PLATE IN AIR
CURVES OF VARIATION WITH LENGTH OF PLATE IN THE TOTAL HEAD OF THE AIR STREAM AT CONSTANT DISTANCE FROM THE PLANE OF THE SURFACE AND IN THE NORMAL PLANE 4·6 INCHES FROM THE CENTRE LINE
WIND SPEED 30 FEET PER SECOND
Fig. 4.
POUNDS PER SQUARE FOOT
PLANE OF OBSERVATION
PLATE
0·2 INCHES FROM SURFACE
0·4 INCHES FROM SURFACE
0·9 INCHES FROM SURFACE
1·38 INCHES FROM SURFACE
1·97 INCHES FROM SURFACE
2·39 INCHES FROM SURFACE
DISTANCE FROM FRONT EDGE IN FEET

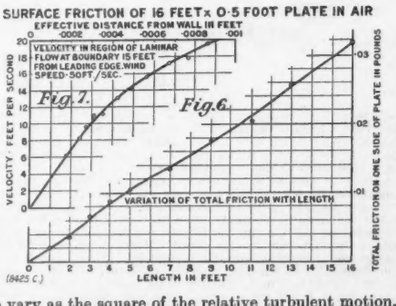

SURFACE FRICTION OF 16 FEET × 0·5 FOOT PLATE IN AIR
CURVES OF VARIATION WITH LENGTH OF PLATE IN THE TOTAL HEAD OF THE AIR STREAM AT CONSTANT DISTANCE FROM THE SURFACE AND IN THE NORMAL PLANE THROUGH THE LONG EDGE
WIND SPEED 30 FEET PER SECOND
Fig. 3.
POUNDS PER SQUARE FOOT
PLANE OF OBSERVATION
PLATE
0·1 INCHES FROM SURFACE
0·2 INCHES FROM SURFACE
0·4 INCHES FROM SURFACE
0·67 INCHES FROM SURFACE
0·9 INCHES FROM SURFACE
1·26 INCHES FROM SURFACE
1·65 INCHES FROM SURFACE
1·97 INCHES FROM SURFACE
(8425 B)
DISTANCE FROM FRONT EDGE IN FEET


SURFACE FRICTION OF 16 FEET × 0·5 FOOT PLATE IN AIR
CURVES OF MOMENTUM LOSS AT AIR SPEED OF 30 FEET PER SECOND
Fig. 5.
MOMENTUM LOSS IN POUNDS PER FOOT WIDTH OF AIR CURRENT
LENGTH OF PLATE IN FEET
TOTAL FRICTION ON ONE SIDE OF PLATE IN POUNDS
5 FEET
HALF WIDTH OF PLATE

in the region of the surface near the edges, and that the flow nearer the suspending wires was not disturbed.

Comparison of the Results with those of other Observers.—It will be obvious from a consideration of the extent to which the flow is affected outwards from the long edge of the plate, that no strict comparison can be made with the results of published experiments which have been carried out on long planks towed in water, for the reason that owing to the exigencies of the method of suspension of the plank one of the long edges has in all cases been either out of water, or, as in Mr. Froude's experiments, only slightly submerged. The comparison, however, is of interest, and is best made with the 50-ft. by 19-in. planks of Mr. Froude, which are nearly geometrically similar to the one here used. For the same value of the scale speed factor $\frac{VL}{\nu}$, the speed of the 50-ft. plank should be 60 ft. per minute, and at this speed the resistance calculated from Mr. Froude's tables would be 0·0037 lb. per sq. ft. Expressing the resistance per square foot as $k \rho V^2$, the value of k for Mr. Froude's 50-ft. plank in water is seen to be 0·00190, and that of the 16-ft. plate in air 0·00188, so that the agreement is closer than would be expected.

Comparison may also be made with the results of Zahm's experiments on plates in air. In these the width of the plate was in all cases 25½ in., and the maximum length 16 ft., so that for dynamical similarity the comparison should be made between a 4-ft. length of the 6-in. plate at 30 ft. per sec., and a 16-ft. length of the 25½-in. plate at 7½ ft. per sec. From Zahm's published results the resistance of the latter would be approximately 0·000343 lb. per sq. ft. The value of k would therefore be 0·0026, as compared with the value 0·0021 for the present experiments. The discrepancy is considerable, and may be, it is thought,


SURFACE FRICTION OF 16 FEET × 0·5 FOOT PLATE IN AIR
EFFECTIVE DISTANCE FROM WALL IN FEET
VELOCITY IN REGION OF LAMINAR FLOW AT BOUNDARY IS FEET PER SECOND FROM LEADING EDGE WIND SPEED 50 FT./SEC.
Fig. 7.
Fig. 6.
VELOCITY FEET PER SECOND
VARIATION OF TOTAL FRICTION WITH LENGTH
TOTAL FRICTION ON ONE SIDE OF PLATE IN POUNDS
(8425 C.)
LENGTH IN FEET

to vary as the square of the relative turbulent motion, its value at this position should be 0·36 times the friction at the leading edge, whereas according to the measured losses of momentum the actual friction was practically the same as that at the leading edge.

Independent Check of the Accuracy of the Momentum Method.—Although in the authors' opinion the apparent lack of agreement of the results of the present experiments with those of other observers, in so far as appreciable falling off in resistance with length is concerned, is sufficiently accounted for by inadequacy in the conditions of similarity and, in the case of water experiments, insufficient depth of immersion, it was felt that any independent check of the method here described would tend to increase confidence in it.

As direct measurement of the distribution of friction over the surface was out of the question, recourse was had to a method developed by the authors a few years ago for measuring the slope of velocity in the thin layer of fluid in contact with the surface which is in the coefficient of viscosity of air at 60° deg. F. as $3{\cdot}57 \times 10^{-7}$ in gravitational measure, the surface friction at 50 ft. per sec. was 0·0123 lb./sq. ft. Assuming the friction to vary as the 1·85 power of the velocity, the surface friction at 30 ft. per sec. would be 0·0048 lb. per sq. ft. From the table in Fig. 5 it will be seen that the frictional resistance of the last 3 ft. of the plate was 0·0042 lb. per sq. ft. Considering the difficulties of the method, this is regarded as a fairly good check.

General Conclusions.—As regards the immediate object of the experiments, the effect of length on skin friction, it is considered that the present experiments prove that skin friction cannot be taken to be dependent entirely on the relative velocity of the surface and the fluid in its immediate vicinity, unless accompanied, as Mr. Froude's remarks would appear to suggest, by some mechanism by means of which the particles of fluid are supplied to the surface at a rate which increases as the distance from the leading edge. Such a mechanism is in agreement with the result of recent investigations, which point to the existence of a coefficient of eddy viscosity which increases in value with the lateral extent of the disturbed motion. The result of this action is that the frictional wake may be regarded as having little or no effect on skin friction.

Further, the results here described lead to the general conclusion that in the experimental study of the friction of rectangular surfaces which are relatively long in the direction of the flow the effect of the lateral dimensions of the surface on the mean intensity of friction cannot be neglected, and in all investigations of the effect of dimensions on the resistance strict geometrical similarity in the models is desirable.

* "Proceedings Royal Society," A, vol. xcvii, 1920.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

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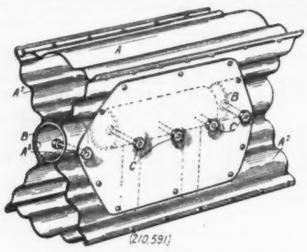
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

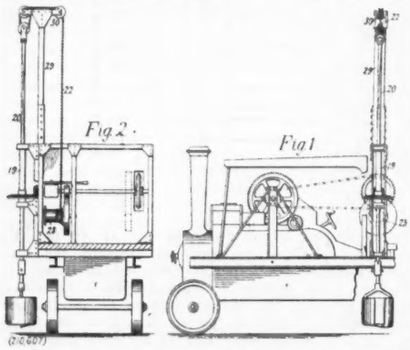
210,591. Armstrong Siddeley Motors, Limited, Coventry, and J. Lloyd, Coventry. Aircraft. (3 *Figs.*) December 19, 1922.—The invention relates to girders of box-like or similar section for use upon aircraft. Each side member A^2 of the girder A at or near the neutral axis is longitudinally grooved



at A^3 so that this part is of parti-circular cross-section. The grooves are engaged with lengths of tubing B, forming hollow distance pieces extending lengthwise of the girder and of such length as is requisite for the reception of bolts C which extend completely through the sides A^2 of the girder and the sides of the distance pieces B also. (*Accepted February* 13, 1924.)

ELECTRICAL APPARATUS.

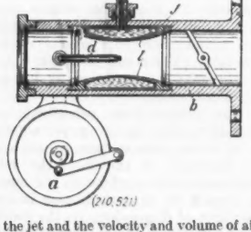
210,607. E. Hole, Burgess Hill. Erecting Electric Telegraph Poles. (3 *Figs.*) January 10, 1923.—The invention provides a simplified construction of apparatus for erecting telegraph poles of the type in which a vehicle has mounted thereon a boring device adapted for boring holes in the ground for the accommodation of the poles. Apparatus of the type mentioned in this invention, comprises a vehicle fitted with a



vertical frame 20 fixed to one side of it, and a drum 23 adapted to be rotated from the power unit of the vehicle. The drum has wound upon it a cable or chain 22 anchored at one end to the frame, passing over pulleys 30 in the frame and a pulley carried by the upper end of an auger shaft 20. A vertical sleeve 19 is adapted to be rotated from the power unit and through this slides the auger shaft 20. (*Accepted February* 13, 1924.)

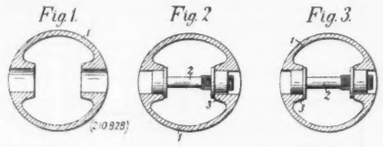
GAS ENGINES, PRODUCERS, HOLDERS, &c.

210,521. C. M. Walker, Four Oaks, near Birmingham. Carburettors. (2 *Figs.*) November 1, 1922.—The invention refers to carburettors of the type in which the effective bore or cross-section of the choke tube may be varied at will to control



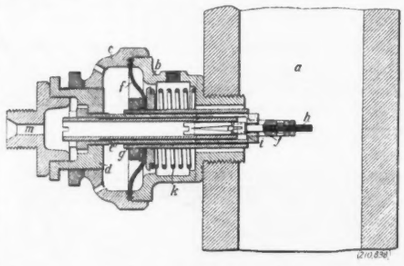
the suction on the jet and the velocity and volume of air admitted, the passage through the choke tube being kept always axial and of substantially stream line form with the object of reducing fluid friction and maintaining the full efficiency of the carburettor over the whole range of control. The object is to provide an improved device for this purpose. The device essentially comprises the provision within a rigid tube of a flexible surface or membrane to which fluid pressure may be applied externally and uniformly around its periphery to cause it to extend to a greater or less extent towards the axis of the tube, the form of the surface or membrane being such that the passage through the tube is of venturi-tube form. The carburettor consists of the usual float chamber *a* and choke tube *b* with a jet *d* arranged axially within the choke-tube and fed with fuel from the float chamber in the usual manner. In the central inner part of the tube *b* is formed a shallow annular recess to receive and retain a hollow annular closed chamber *j* of rubber. The outer wall of the chamber *j* lies against the wall of the tube *b* and the inner wall *l* forms the expansible surface or membrane. Leading into the chamber *j*, is a short tube which passes through the wall of the choke-tube *b* and is connected by a pipe to a reservoir containing a liquid or gas under pressure. Pressure applied to the liquid or gas will be transmitted to the sleeve *j* and will cause the inner wall *l* of the sleeve to be expanded inwards to restrict the bore through the choke-tube *b* to a greater or less extent dependent on the pressure applied. (*Accepted February* 13, 1924.)

210,828. S. Smith, Gunnersbury, London, and A. C. Cars, Limited, Thames Ditton. Pistons. (5 *Figs.*) October 18, 1922.—The invention relates to pistons of the trunk type. The method of manufacturing pistons, according to the invention, is first to turn the piston 1 to a diameter which is slightly above the correct finished diameter as shown in Fig. 1. An expanding member 2 is then placed inside the hollow piston so as to act at two points adjacent to the two gudgeon pin bosses 3. The piston 1 now assumes an oval or elliptical cross-section, as shown



in Fig. 2, with its greatest transverse dimension parallel with the axis of the gudgeon pin. With the expanding device still in position, the piston is set up in a grinding machine and its exterior is ground truly cylindrical to the required dimensions. When the grinding is finished, the expanding device is removed and the piston contracts along the axis of the gudgeon pin, as shown clearly in Fig. 3, until it again assumes an elliptical form in cross-section, but with the maximum transverse dimensions of the ellipse at right angles to the gudgeon pin. (*Accepted February* 20, 1924.)

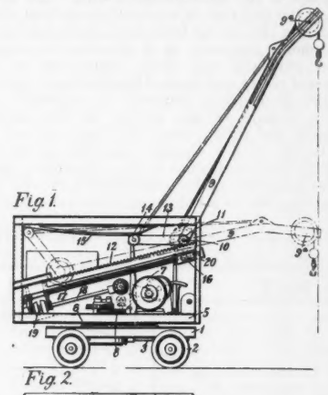
10,898. C. T. Carr, Sandiway, near Northwich. Internal Combustion Engines. (1 *Fig.*) November 16, 1922.—The invention relates to means for supplying water in atomised form to the charge being drawn into the cylinders of internal combustion engines. *a* indicates a part of the engine induction pipe between the carburettor and the engine inlet valves. The device, which is adapted to be secured upon the induction pipe, comprises a casing *b* which has threaded upon it a cap *c*. A plug *d* screws into the cap and carries a central nozzle-like part *e*, which projects into the induction pipe. A diaphragm *f* clamped between the parts *b* and *c* is secured at its centre to a sleevelike part *g* disposed around the nozzle *e*. The end of the sleeve *g* is provided with a part *j*, which projects into the induction pipe and carries the stem *h* of the valve *i* adapted to seat within the end of the nozzle *e*. The diaphragm *f* and hence the sleeve *g* and part *j* are adapted to move under the action of the vacuum in the engine

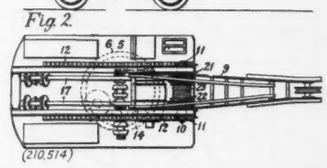


induction pipe against a spring *k*. With the arrangement described, when the vacuum in the engine induction pipe is high, that is, when the throttle valve is nearly closed, the diaphragm closes the valve *i* on to its seat within the end of the nozzle *e* and when there is no vacuum in the induction pipe, that is, when the engine is not working or when the vacuum is less than a predetermined amount, the spring *k* forces the diaphragm into a position in which the part *j* seats on the end of the nozzle and closes the outlet therefrom. It will be seen, therefore, that under high vacuum and no vacuum conditions, the end of the nozzle *e* within the induction pipe is closed. Water is supplied to the nozzle from the water inlet connection *m*. Under low vacuum conditions, that is, when the engine is under load, the diaphragm and the valve *i* and part *j* which it controls are in a mid-position, and water is drawn through the nozzle into the induction pipe. (*Accepted February* 20, 1924.)

LIFTING AND HAULING APPLIANCES.

210,514. R. A. Smith, Westminster, London, and T. Meacock, Southend-on-Sea. Cranes. (2 *Figs.*) October 31, 1922.—The invention relates to cranes of the kind comprising a luffing jib and winding gear mounted on a wheeled carriage provided with a motor and steering device so that the carriage can be driven from place to place on ordinary road surfaces. 1 is an under carriage mounted on road wheels 2. A platform 5, mounted on a turntable support 6 on the under-carriage 1, carries a motor 7 geared to the shaft 3 and to gearing 8 by which the platform 5 may be rotated on the under-carriage 1. A jib 9 is pivoted upon a shaft 10 carrying pinions 11, which are arranged to travel along inclined racks 12. Extensions 13 of the jib 9 carry rollers 14, which reravel along cam paths 15 inclined to the racks 12. When the shaft 10 is at the right-hand end of the racks 12 the jib is supported in the raised position, shown in full lines, by the extensions 13 and rollers 14 bearing against the cam paths 15. When the shaft is at the left-hand end of the racks the jib is lowered to the position indicated in broken lines. Whilst the jib is moving between these two positions the jib head 9a will move along a substantially vertical line so that the tilting moment exerted on the carriage by a load carried on the jib will remain practically constant since the radius at which it acts is not substantially changed. The shaft 10 is mounted in housings 16 sliding along shafts 17 driven by the motor 7 through the shafts 18 and reversing clutches 19. Worms 20 respectively rotating with the shafts 17 and sliding thereon are held within the housings 16. One of these worms is in gear with a worm wheel 21 keyed to the shaft 10 to drive the pinions

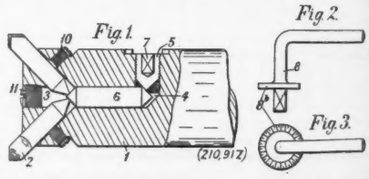




11 and the other worm is in gear with a worm wheel 22 coupled to a winding drum 23 mounted on the shaft 10 co-axially with the pivotal support of the jib so that as the angle of inclination of the jib is varied the load suspended by the winding rope 24 on this drum remains at the same distance below the head sheave of the jib. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, ETC.

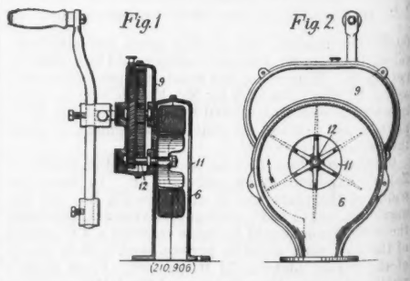
210,917 C. Rothwell, Milnrow. Boring-Bars. (5 *Figs.*) December 1, 1922.—The invention relates to boring-bars with expanding cutters of the type in which the cutters are expanded by means of a plunger movable in an axial bore in the cutter-bar and operated by an adjusting-screw working in a passage at right angles to the axial bore. The boring bar 1 has four expanding cutters 2 radially arranged at 90 degrees apart, an axial bore 3, and a second passage 4 meeting the rear end of the axial bore 3. The passage 4 is tapped to receive the adjusting screw 5. The bore 3 contains a round plunger 6 tapered at each end. The adjusting screw 5, which bears against the back end of the plunger 6, has in the top a hole 7 into which fits the correspondingly.



shaped bottom end of an adjusting key 8, illustrated in Figs. 2 and 3. The key has a suitable handle. A collar 8b on the shank of the adjusting key is graduated. The four cutters 2 are located in inclined passages which enter the bore 3 and are secured by grub-screws 10. The cutters are tapered at their inner ends to allow them to come together to a point, and upon such ends of the cutters the forward tapered end of the plunger 6 acts. By turning the adjusting screw 5, therefore, by means of the key 8, the cutters 2 can be expanded to the desired extent and are then secured in their adjusted position by tightening up the grub-screws 10. The axial bore 3 is closed at its forward end by a grub-screw 11 to keep out dirt. (*Accepted February* 20, 1924.)

MINING, METALLURGY AND METAL WORKING.

210,906. W. R. Platten, South Norwood, London, and P. W. Allday, Solihull. Smiths' Forges. (3 *Figs.*) November 21, 1922.—The invention consists of a blower for smiths' forges having a pear-shaped formation of casing, and is characterised by the eccentric displacement of the rotor relative to the casing, by a corresponding eccentric displacement of the air



inlet aperture 11 in the casing 6 and by the motion transmitting gear the casing 9 of which is so mounted on the rotor spindle 12 that one or other of the two casings may be rotated for the purpose of setting them in such varying positions relative to each other as circumstances may render expedient. (*Accepted February* 20, 1924.)